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**A FIRST LABORATORY GUIDE  
IN PSYCHOLOGY**

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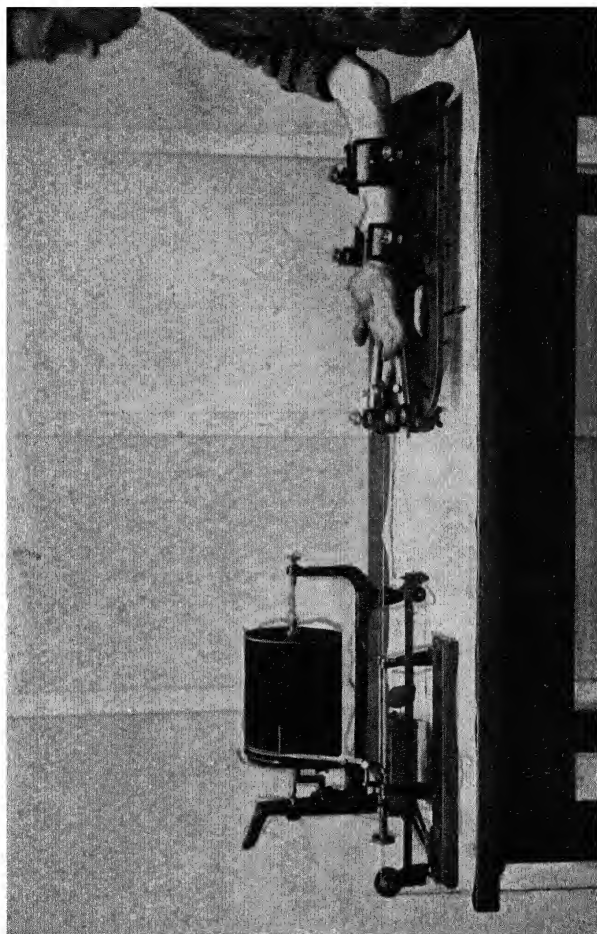
BY JAMES DREVER

THE PSYCHOLOGY OF EVERYDAY LIFE

THE PSYCHOLOGY OF INDUSTRY







MOSSO'S ERGOGRAPH

# A FIRST LABORATORY GUIDE IN PSYCHOLOGY

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## PREFATORY NOTE

**T**HE purpose of this volume, which is supplementary to "An Introduction to Experimental Psychology" by the same authors, is to supply a laboratory guide which may be put in the hands of first-year students of Psychology. It is possibly a counsel of perfection to recommend that, in this as in other sciences, practical work should accompany theoretical lectures from the very beginning. It is at least certain that no first-year's course without practical work can be regarded as satisfactory.

The selection of the experiments included is based on the work actually done in the first-year's course in the George Combe Psychological Laboratory. It is not intended that all the students should perform all the fifty experiments. Twenty experiments would appear to be as much as one can reasonably expect even the best students to carry out in an experimental course of not more than sixty hours, which may be taken as the normal period that can be devoted to experimental work during a first year in Psychology. The additional experiments described, therefore, will afford opportunity and scope for arranging a course suitable to the needs of the students and to the resources of the laboratory.

The experiments are described in sufficient detail as regards apparatus, procedure, etc., to obviate the necessity of having the instructor's time at the beginning of each experimental session occupied in giving directions to the students with respect to the conduct of the experiment. All he need do is to tell the students to carry out "Experiment No.—." In this way also it will be found possible to deal with larger experimental sections, since it is no longer essential that all the students should be doing the same experiment.

The authors desire to place on record their indebtedness to the late Mr. L. Inglis Collins for the drawings for the figures in the text.

M. C.  
J. D.

EDINBURGH  
*September, 1926*

## PREFATORY NOTE TO THIRD EDITION

**I**N the present edition a number of new experiments will be found, the total number having been increased from *fifty* to *sixty-six*. In addition, as a result of the experience of the authors in using the book with first-year students, fuller directions have been given in certain experiments.

M. C.  
J. D.

EDINBURGH,  
*August, 1946.*

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# A FIRST LABORATORY GUIDE IN PSYCHOLOGY

## GENERAL DIRECTIONS

THE experiments which follow are for the most part arranged for students working in groups of two.

In such cases each of the students will act alternately as Experimenter (E) and as Subject (S). In general, directions will be given indicating at what point the change-over ought to take place.

The order of the experiments need not be rigidly adhered to. On the whole the arrangement approximates the order in which the experiments are taken in the George Combe Psychological Laboratory, and also the order in which the topics are discussed in Collins and Drever's "Experimental Psychology." It ought to be added, however, that the early experiments are intended to introduce the student to the essential technique of psychological experimentation, and if other experiments are preferred for this purpose, care should be taken to see that they are utilized in such a way as to attain the end in view.

The early experiments can all be arranged either as *one hour* or as *two hour* experiments. Whenever possible two



hours should always be assigned for a laboratory period, but this may not be always possible.

**Keeping of Notes**—A careful record should be kept by every E. of each experiment he performs. The record should be sufficiently detailed to enable a reader to repeat the experiment exactly as E. performed it, and to understand precisely the results that E. obtained. The actual writing up of the experiment in this form may be left over till later, but E. must keep a sufficiently detailed record of the experiment in the shape of rough notes at the time to enable this to be done.

The notes on each experiment should show :—

- (1) Date (day and hour) of the experiment.
- (2) Name of S.
- (3) General condition of S. as to health, fatigue, etc.
- (4) Problem to be studied.
- (5) Apparatus and material.
- (6) Method employed (in detail).
- (7) Results.

In many of the experiments tables are given in order to guide the introspection of the subject. Any further points which appear to the S. to bear on the results of the experiment should be recorded. It is better that introspection should be too full than too meagre.

## PRELIMINARY EXPERIMENTS

### EXPERIMENT 1

#### *Free Association: (a) Continuous Method*

**Problem**—To study an individual's train of thought, and the factors determining the succession of his ideas.

**Apparatus and Material**—Two cards marked A and B respectively, each with list of stimulus words (one student should have A, his partner B, and neither should see the other's card).

**Procedure**—The experiment is carried out simultaneously by the various groups. At the word "ready" from the Instructor, each S. will close his eyes. At the word "go" each E. will give a stimulus word, beginning with the first on his list. S. will speak aloud words or ideas suggested by this stimulus word as rapidly as they occur to him, and without stopping to consider or criticize the words that come, continuing till the Instructor rings a bell at the end of one minute. E. will record the words as S. says them. E. and S. will then go over the words together, tracing the connections and trying to explain them.

After the experiment has been completed with one stimulus word the second will be taken, and the experiment repeated. E. and S. will then change over, and the new E. will take the words on his card. After two words have been taken, E. and S. will change functions again, and work

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through the lists in this way (there ought to be six words on each card).

**Treatment of Results**—Find the mean Association Time from the results with the last three stimulus words. This allows the first three for practice.

Classify the associations. For Classification of Associations, see Collins and Drever, "Experimental Psychology," Chapter XII.

**Note**—The cards of stimulus words may be prepared by each E. beforehand, words like *Christmas, fire, money, yesterday*, etc., being used.

### *Free Association : (b) Word List Method*

**Problem**—To study the word reactions of S. to a list of stimulus words when he is left free to reply with the first word that comes to mind.

**Apparatus and Material**—A list of words such as the Kent-Rosanoff list or Jung's list. Stop-watch.

**Procedure**—E. makes up list of words for practice.

1. *Preliminary*.—E. says "Ready" to S. then about two seconds later reads off the first word, at the same time starting a stop-watch. S. has to reply with the first word which the stimulus word brings up in his mind. Whenever S. gives the reply, E. stops watch and records the time. S. should in each case endeavour to trace the connection between stimulus word and response. Then give a second word in same way, and repeat until practice series is completed. The normal time of response should be between one and two seconds. If S. finds difficulty in replying to a word, allow thirty seconds and then note failure to reply.

2. *Experiment Proper*—Repeat as in preliminary ex-

periment but now using the list of words decided on. Subject should change functions after every twenty-five words.

**Treatment of Results**—If using the Kent-Rosanoff list, the results can be compared with the results of the 1000 normal subjects tested by Kent and Rosanoff and the frequencies noted. (See *American Journal of Insanity*, Vol. 67.) In addition try to trace out what laws are operating in determining the replies and classify the associations. Note the faults (i.e. the cases where S. failed to give a reply) and the lengthened reactions, etc., and see what explanation S. can give of these.

## EXPERIMENT 2

### *Constrained Association*

**Problem**—To study responses of S. when the response word must bear some definite relation to the stimulus word.

**Apparatus and Material**—Lists of words. Stop-watch.

**Procedure**—The constrained association may take different forms, according to the relationship prescribed in any particular experiment. The procedure is as in previous experiment.

1. *Partially Constrained Association*.—Co-ordination. E. will draw up a series of twenty words composed of names of birds, animals, trees, flowers, metals, etc., arranged in haphazard order, and instruct S. to reply in each case with the name of one of the same class.

2. *Wholly Constrained Association*.—Opposites. E. will draw up a series composed of words which have opposites such as large, white, day, humility, etc., and S. is instructed to reply by giving the opposite in each case. Other types of constrained association may be employed such as part-whole, e.g. bow, ship; and analogies—grass : green = sky : ?

**Treatment of Results**—Times should be recorded as usual and compared with those of the previous experiments. S. should also endeavour to say what processes are involved in arriving at the responses.

## EXPERIMENT 3

### *Imagery. Word List Method*

**Problem**—To investigate an individual's imagery by the Word List Method.

**Apparatus and Material**—Two sheets of paper marked A and B respectively, one for each E. On each sheet is a list of twenty-four words, in two columns of twelve words each. The words must be so selected as to be in each column fairly representative of the different sense departments, such as: *grass, bugle, velvet, ammonia*. The lists may be prepared by each E. before the experiment. Cover-sheet with aperture just large enough to reveal one word.

**Procedure**—1. *Visual Presentation*—Use words in left-hand column only. S. closes eyes, and E. arranges aperture to show first word on list. At word "now" S. looks at word exposed, and gives an account of the imagery immediately called up by the stimulus. E. fills up Table below from the introspection of S. Repeat with each word in list, E. and S. however interchanging functions at the end of six words.

2. *Auditory Presentation*—Use words in right-hand column. S. closes eyes at word "ready," and E. reads off the first word on list. E. fills up the Table as before, and goes on through the list, changing functions with S. after six words.

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Stimulus Word.	Object Images.	Type.	Vividness.	Word Images.	Type.	Vividness.
			1. Strong. 2. Medium. 3. Slight.			

**Treatment of Results**—Find out from Table the predominant type of imagery and how far the type changes with change in method of presentation.

## EXPERIMENT 4

### *Receptive Imagery* (after W. G. Smith)

**Problem**—To investigate an individual's imagery.

**Apparatus and Material**—Metronome. List arranged by E. beforehand of experiences belonging to various sense departments, as follows :—

1. Colour of orange.
2. Noise of thunder.
3. Softness of velvet.
4. Smell of tobacco.
5. Taste of sugar.
6. Sensation of thirst.
7. Coldness of ice.
8. Pain of prick.
9. Exertion of running.
10. Effort of shouting.

**Procedure**—This may be conducted as a group experiment. The metronome is set at 60. E. reads off the first of these stimulus phrases at the rate of one word per second. The first word calls up the general class to which the image belongs, and directs the thought of S. towards the experience. The third word indicates the special object and defines the image. Just as the third word is said by E., S. closes eyes. At the end of five seconds E. says "write," and S. will then commence to fill up the



columns in the Table below. Repeat in same way with rest of list. To get the time of appearance of the image, E. will count aloud the beats of the metronome in the five seconds allowed for the appearance of the image. The image may appear at 2, 3, 4, etc., and the time is noted accordingly. The fourth column in the Table is "Response." The image may come directly or indirectly. If it does not come directly S. should note the means by which he called it up.

Time of Appearance.	Clearness.	Intensity.	Response.	First Word Given.
	Clear. Medium. Obscure.	1. Great. 2. Medium. 3. Slight.	Direct or Indirect.	

## EXPERIMENT 5

### *Estimation of Extent of Movement*

**Problem**—To investigate the conditions affecting the estimation of the distance through which the hand moves.

**Apparatus and Material**—Two rulers placed end to end at chalk mark near edge of table (at such distance from edge that the forefingers can be moved along edge without displacing rulers).

**Procedure**—S. is seated facing table with chalk mark opposite median line of body, with eyes closed, and with the forefingers of both hands placed together at chalk mark. The experiment is divided into four parts. In the first two the hands are moved outwards simultaneously along the edge of the table; in the other two they are moved successively, first the right hand and then the left, or *vice versa*. Care should be taken on the part of S. to keep the rate of movement of the hands constant.

The distance to be estimated by S. is determined by E., who places his pencil as a stop in front of one of the moving hands at a point he has previously resolved upon. This distance is the standard in each case, which S. must estimate by stopping the other hand after it has moved the same distance.

The right hand is taken as the standard in the first series (8 estimates), then the left hand (8 estimates), then the left hand again (8 estimates), and finally the right

hand (8 estimates). E. and S. should change functions after every series. Record in tabular form *after each estimation*, embodying the results of the introspection of S.

**Treatment of Results**—The first three experiments should be reckoned as practice in each series, so that only the last five in each case will be used for the calculation of results.

Calculate mean percentage error in each case.

Calculate also mean error (with sign) in each series.

This is given by the difference between sum of standard distances and sum of estimated distances divided by 5.

Standard.	Estimate.	Error.	Certainty.	Criteria.		Re- marks.
				Sensa- tion.	Image.	
			1. Great. 2. Medium. 3. Slight.			

## EXPERIMENT 6

### *The Statistical Treatment of Data*

In all quantitative experiment we repeat a measurement a number of times, and thus obtain a number of varying individual measurements. To condense these into a single measurement we take the mean (or sometimes the median). The mean is, as it were, a summary of our results. The formula for its calculation is:  $M = \Sigma(a)/N$ , where  $\Sigma(a)$  is the sum of the individual measurements, and  $N$  the number of such measurements. The same formula gives the mean for the group when we measure a group of individuals with respect to any character or ability.

Along with a mean must always be given some indication of the variability of the individual measurements. This may be either the mean variation (MV) or the standard deviation ( $\sigma$ ). To get the MV we calculate the differences between the mean and each of the individual measurements, and take the mean of these, regardless of sign. The formula is thus:  $MV = \Sigma(d)/N$ , where  $\Sigma(d)$  is the sum of the differences between the mean and the individual measurements, regardless of sign. The formula for the standard deviation is—

$$\sigma = \sqrt{\frac{\Sigma(d^2)}{N}}.$$

That is to say, we square the individual differences from the mean, add these squares, divide by the number of cases, and then take the square root. The standard deviation is thus the square root of the average of the squares of the individual differences from the mean.

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To obtain the median or middle value, the individual measurements must first be arranged in order of magnitude. The median or middle value is the  $(N + 1)/2$ th value. If there is an even number this will fall between two of the individual measurements, and the mean of these must be taken. For example, if we have 19 individual measurements, the median is the  $(19 + 1)/2$ , that is the 10th from either end; if we have 20, it is the  $(20 + 1)/2$ , that is, the average of the 10th and 11th. The same procedure is followed when we are dealing with measurements for a group of individuals. The measure of variability given with the median is called the "probable error" (PE), and is obtained by calculating half the difference between the quartiles, that is the values midway between the median and each extreme.

To determine the relationship between two series of measurements for the same group of individuals, the correlation coefficient ( $r$ ,  $\rho$ , or  $R$ ), or the association coefficient is calculated. There are three more or less standard methods of obtaining a correlation coefficient. For the first the Pearson "product-moments" formula is used, which is

$$r = \frac{\Sigma(xy)}{N\sigma_x\sigma_y} \quad . \quad . \quad . \quad (1)$$

where  $x$ ,  $y$  are the deviations from the mean of the same individual in the respective series (with the sign), and  $\sigma_x$ ,  $\sigma_y$  the respective standard deviations of the two series. That is, we multiply the deviation of an individual's score from the mean in the first series by the deviation of the same individual's score from the mean in the second series. Do this for every individual, add the products, and divide by the product of the two standard deviations multiplied by the number of individuals. For the second method

we employ the Spearman "ranks" formula. This formula, as well as the next, is employed when it is more convenient to arrange the individuals in rank order, or when no real measurement, but only ranking, is possible. The formula is

$$\rho = 1 - \frac{6\Sigma(d^2)}{N(N^2 - 1)} \quad . \quad . \quad . \quad (2)$$

where  $d$  is the difference between an individual's rank in the first test, and his rank in the second. Thus, if an individual is ranked 2nd in the first test, and 5th in the second, the difference between his ranks is 3. These differences are squared, the sum of all the squares for the different individuals multiplied by 6, divided by the product  $N(N^2 - 1)$ , where  $N$ , as before, is the number of individuals, and the result deducted from unity. For the third method we employ Spearman's "footrule" formula which is

$$R = 1 - \frac{6\Sigma(g)}{N^2 - 1} \quad . \quad . \quad . \quad (3)$$

where  $g$  is the number of places gained in the second test. In this case we take account only of those instances where an individual has gained in rank in the second test as compared with the first.  $\Sigma(g)$  is the sum of such gains.

The formula for the association coefficient is

$$\frac{\sqrt{ab} - \sqrt{cd}}{\sqrt{ab} + \sqrt{cd}} \quad . \quad . \quad . \quad (4)$$

where  $a$  = number of individuals above the mean or median in both series.

$b$  = number of individuals below in both.

$c$  = number above in first and below in second.

$d$  = number below in first and above in second.

**Exercise**—Calculate  $M$ ,  $MV$ ,  $\sigma$ ,  $r$ ,  $R$ ,  $\omega$ , for the following two series :—

Individual.	First Series.	Second Series.
A	47	37
B	79	68
C	68	62
D	76	69
E	53	46
F	57	63
G	65	60
H	67	59
I	63	56
J	60	50
K	78	71
L	72	66
M	80	64
N	61	57
O	59	51
P	69	55
Q	55	43
R	65	58
S	64	54
T	62	41

## EXPERIMENT 7

### *The Relation of Speed and Accuracy.*

(Adapted from Langfeld and Allport.)

**Problem**—To determine by means of the correlation coefficient the relation between speed and accuracy.

**Apparatus and Material**—Stop watch. Series of letters (which should be duplicated) as below :—

brlteyelrmpykecathilmpewrbedxaumtinrtmoxkcrytsoobmg  
lideipysirncedfkjhigyxpekvtoklvneiillzcuynvewoioupytmg  
bhtabtarsxuefddogmkjiopynlidtopsdfhghutbrdenexertfisa  
clieyurnrednjidrasswygfwcani jkwcryyhwusoumiofwitlipqh  
vluqxvhtownquwcaceweardf ivepwamgoiscexed luratmnkli  
ponmopmxefkghuyttageblyfctiprijseapveruytwomibrylegq  
uietrycasertlmxtenkrndigertrt gtenvlu yrcxf urrhythmhyss  
pthlochtxmintrwblbyryekpanecfgvred.

**Method of Procedure**—S. is instructed to underline as rapidly as possible all the groups of consecutive letters making words, e.g. "red." A single letter does not count as a word. If the same letters are used in more than one word, as "that," "hat," "at," a separate line must be drawn for each word. If the experiment is carried out as an individual experiment, E. must not see the words



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underlined by S. The time taken to underline all the words S. can find is recorded. The results are tabulated for the whole group according to the following table :—

Subject.	Time in secs.	No. of Errors.	M.V. Time.	M.V. Errors.	Rank for Speed, $R_1$ .	Rank for Errors, $R_2$ .	$d =$ $R_1 - R_2$ .	$d^2$ .

The correlation coefficient between speed and accuracy is calculated by the formula

$$\rho = 1 - \frac{6\sum(d^2)}{N(N^2 - 1)}.$$

## EXPERIMENT 8

### *Method of Mean Error*

**Problem**—To measure the Müller-Lyer illusion, using the method of mean error, and to calculate the space error.

**Apparatus**—2 forms of the Müller-Lyer figure (arrow-head and feather-head). 1 cover sheet, 2 sheets of ruled foolscap.  $\frac{1}{2}$  sheet of foolscap. Metronome.

**Procedure**—One sheet of foolscap and one form of the figure are for the use of one S., the other sheet of foolscap and the other form of the figure are for the use of the other S. E. will draw a vertical line in pencil parallel with the edge of the paper and 2 inches from it. E. will then place the sheet of foolscap directly in front of S., with the illusion at his left-hand side in juxtaposition with edge of foolscap and so arranged that the horizontal line of the figure will be on the same level as the first line of the foolscap. The plain cover sheet is now placed over the figure. E. says "ready" to S., counts two beats of the metronome (which is beating in seconds) and uncovers the figure. S. then has to estimate the length of the horizontal line of the figure and reproduce its length merely by placing a dot on the first line of the foolscap so that the distance between it and the vertical line on the paper is equal to the line of the figure. The half sheet of foolscap is used to place over S.'s reproduction. The first reproduction is slipped up under it, so that the second line of foolscap

is on a level with the horizontal line of the figure, and in position for the second reproduction. This entire procedure is repeated each time until 10 reproductions have been made by S., each reproduction one below the other using the first 10 lines of the foolscap. S. is allowed to take his own time for reproduction, and to fixate illusion before reproducing as long as he wishes.

The experiment is then repeated in exactly the same way but with the *same* illusion placed to right of foolscap. From these two sets of reproductions can be calculated the space error.

Repeat as above with other S., using the other form of the figure. Each S. should only do 10 estimations at a time and then functions should be changed.

**Tabulation of Results**—This table should be filled in by E. after every estimation of S. and is dependent upon S.'s introspection, except as regards eye-movements which E. himself should note and record.

Trial No.	Process of Estimation.		Judgment of Accuracy.	Length Estimated.	Error.
1	<i>Attention</i> fixed or fluctuating	<i>Eye movements—</i> 1, 2, 3, or many	(To be filled up from S.'s introspec- tion.) 1. Great. 2. Medium. 3 Slight		
2					
.					
.					
.					
.					
.					
10					

The last two columns should not be filled up till end of experiment.

**Treatment of Results**—(1) Mean error of estimation or crude constant error = difference between standard distance and mean of estimates. This is usually written  $e_1$  on the right-hand side, and  $e_2$  on the left-hand side.

(2) Mean variation =  $\frac{\Sigma(d)}{N}$  = sum of the deviations from the mean, regardless of sign, divided by the number of cases.

(3) Space error =  $\frac{e_1 - e_2}{2}$ .

## EXPERIMENT 9

### *Method of Mean Error—Metre Rod*

**Problem**—To mark off on a rod a distance equal to a standard distance using the method of mean error.

**Apparatus**—Galton's metre rod supported on two retort stands. Three riders. Two paper knives for adjustment of riders. Screen of grey paper as background. Stop-watch.

**Procedure**—(1) S. is seated at the table on which rests apparatus, the metre rod with plain side facing him. E. stands at other side of table from which he can see the scale on the rod. One rider is placed in centre of rod, a second is placed to the right (or left) of this at a distance of 20 cm. The distance between these two riders is the standard distance, and is kept constant throughout a series. The third rider is placed to the left (or right) of the central one at varying distances, and is known as the variable. E. will arrange a series so that the variable is in five cases much greater ( $\gg$ ) than the standard, 5 cases greater ( $>$ ), 5 cases less ( $<$ ), 5 cases much less ( $\ll$ ), these 20 to be presented to S. in chance order.

(2) E. places variable rider to the first distance as drawn up in the series. E. then says "ready" to S. who picks up one of the paper knives provided for adjustment, and then fixates a chalk cross drawn upon the table directly

in line with the centre of the rod. About 2 seconds later, E. says "Go"! at the same time starting a stop-watch, whereupon S. begins to adjust the variable until it seems to mark off a distance equal in length to that of the standard. When S. is satisfied that the distance is correct, he says "right" to E. who immediately stops the watch and records the time. S. will then write his introspection while E. records the result of S.'s adjustment of the variable and places the variable in position for the second trial. In this way a practice series of 10 estimations should be carried through. Then the 20 estimations constituting the experiment proper should be commenced. S. will record his introspection distinguishing the periods (1) between the commands "ready" and "now"; (2) during the actual adjusting; (3) immediately after. E. records his results as in Table.

Distance of Variable.	Subject's Estimation.	Error.	Time in Secs.

It is advisable for S. and E. to change functions after every 10 estimations.

In order to obtain the space error, repeat experiment with standard to left-hand side and variable to right (or *vice versa*).

A second set of measurements with standard right and left should be made with standard equal to 30 cm.

**Treatment of Results**—(1) Find the crude constant error. (a) with standard to right, (b) with standard to left. This is done by taking the difference between the average of S.'s estimations and the standard.

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(2) Find the mean deviation—the deviation of each individual estimate from the mean, irrespective of sign, divided by the number of cases.

(3) Find the space error. The space error equals the crude constant error on the left-hand side minus the crude constant error on the right-hand side, divided by 2.

Repeat with results from standard at 30.

## EXPERIMENT 10

### *Absolute Localization of Point on Skin*

**Problem**—To investigate the accuracy of localization of a pressure on the back of the hand.

**Apparatus and Material**—Ruler. Pair of dividers. Two pointed wooden rods. Metronome 60, with bell at every 4. Architects' tracing paper.

**Procedure**—E. makes two life-size maps of back of S.'s left hand by tracing on architects' paper, and marks in all visible landmarks, such as veins, etc. On one of these maps E. marks the points to be stimulated, distributing them over the back of the hand, and numbering them in the order in which they are to be stimulated from one to ten. This map must not be seen by S. The other map is placed in front of him. A preliminary practice is taken on the right hand of S. S. rests his hand lightly shut in a comfortable position on the table in front of him with the back of the hand up, and closes his eyes. E. says "ready," and on the next bell of the metronome brings down the point of his rod not too firmly on the point to be stimulated, removing at the third beat. S. opens his eyes, and without looking at the back of his hand attempts to locate the point stimulated on the map in front of him.

After a few practice experiments on the right hand the experiment proper is begun, and the same procedure is followed. When S. has localized a point E. marks it on



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S.'s map, then places one map over the other, and with the dividers measures the error, filling in the Table below for each point at the time. S. should be kept ignorant of the magnitude and direction of errors. His own judgment of accuracy should be recorded in each case. E. and S. should change functions after five experiments.

The experiment may be conducted more simply, though under somewhat different conditions by making S. localize on his own hand, keeping his eyes closed. In this case only one map is required.

Point Stimulated.	Error in mm.	Direction of Error.	Judgment of Accuracy.	Imagery.
.		Peripheral (P.)	1. Great.	
.		Central (C.)	2. Medium.	
.		Radial (R.)	3. Slight.	
.		Ulnar (U.)		
10				

## EXPERIMENT 11

### *The Spatial Threshold*

(The Æsthesiometric Index)

**Problem**—To determine the spatial threshold or the æsthesiometric index (*a*) longitudinally, (*b*) transversely on the back of the left hand by the Method of Limits.

**Apparatus**—Æsthesiometer. Metronome set at 60.

**Procedure**—S. is seated with closed eyes in front of table on which rests his hand in a comfortable position and lightly closed. The back of the hand is the part to be explored. E. marks with an ink-spot the centre of the portion to be investigated. The æsthesiometer must be brought down on S.'s hand to the beat of the metronome, and kept down for two beats, that is giving a stimulation of 2 seconds each time.

**Preliminary Experiment**—The preliminary experiment is carried out on the back of the *right* hand. E. sets æsthesiometer at 40 and says "ready" to S. At the next beat of the metronome, E. then brings the two points down on the back of S.'s hand, longitudinally, taking care that the two points are applied simultaneously.

S. then records whether he feels the two points stimulating his skin or whether only one. E. places the æsthesiometer at 35, and repeats in the same way, then at 30, 25, 20, etc., until S. gives the answer "one" twice in succession. The average of the points between which the change from two to one takes place gives an approximate or a "rough" threshold. This rough threshold is then approached from different directions as described in the experiment proper.

**Experiment Proper**—The experiment proper is carried out on the back of the *left* hand. The Method of Limits consists of a descending series in which the rough threshold is approached from a point higher than itself, that is where S. has no difficulty in experiencing the two points as two: and of an ascending series in which the rough threshold is approached from a point below it, at which S. is only able to experience a one-point sensation. E. begins with the descending series. E. sets the æsthesiometer at a point about 9 or 10 mm. above point of rough threshold and decrease distance regularly, 1 mm. at a time until S. gives the answer "one" twice in succession. E. stops the series immediately. For the ascending series E. sets the æsthesiometer at a point about 5 or 6 mm. below where the descending series stopped and increases regularly 1 mm. at a time until S. gives answer "two" twice in succession.

The threshold is found by taking the average between the last point at which S. gives the answer "two" in the descending series and the last point at which S. gives the answer "one" in the ascending series.

Care must be taken throughout to make the steps equal and regular both in the ascending and in the descending series. No catch experiments are to be introduced.

**Tabulation<sup>1</sup> of Results** to be completed after every step.

Distance in mm.	Judgment.	Subject's Certainty.	Feeling.	Other Observa- tions.
	1 { Elongated or simple.	1. Great.	Pleasant.	
	2 { Separate or connected.	2. Medium. 3. Slight.	Unpleasant. Indifferent.	

If time allows repeat in exactly same way, but applying the æsthesiometer transversely to skin.

<sup>1</sup> See Collins and Drever, p. 124.

## EXPERIMENT 12

### *Spatial Threshold by Method of Serial Groups*

**Problem, Apparatus, and Material** as above.

**Procedure**—(1) A preliminary practice series as with the Method of Limits in which an approximate threshold is obtained.

(2) The æsthesiometer is set at a distance 5 or 6 mm. above this approximate threshold. This distance is to be given S. ten times along with ten catch stimuli—that is with only one point touching the skin. The twenty stimuli, with the catch experiments irregularly distributed, constitute a single series. When only one point is used E. should stimulate the skin near one of the places where either of the two points stimulates it, not in the centre between the two. It is convenient to record the results in two lines, the upper referring to two point stimulations, the lower to one point stimulations, thus:

RRRXRRRXRR

RXRRRRXXRR

R signifying a correct reply, and X a wrong. If all are correct in the top line, E. repeats the experiment giving another twenty stimulations, but with the æsthesiometer set at 2 mm. less. If again all are correct E. reduces the distance by another 2 mm., and goes on with another series. The threshold is taken as the lowest value which gives 80 per cent. correct replies, that is two errors, in the top line, and E. will therefore continue reducing the distance until he gets more than two errors.

## EXPERIMENT 13

### *Right and Wrong Cases*

#### (Lifted Weights)

**Problem**—To determine the threshold for lifted weights using the method of right and wrong cases.

**Apparatus and Material**—Fechner's weights with holders and a circular revolving table covered with baize. Retort stands with cord stretched across to determine height of lift. Screen behind which E. can arrange weights.

**Procedure**—*Arrangement of Series*—Let standard weight be equal to 1780 grammes inclusive of holder. The variable weights are five in number, two on each side of the standard and one equal to the standard, with a regular difference of 50 grammes, so that the variables will have the following weights, inclusive of holders:—

- |     |                                       |                   |
|-----|---------------------------------------|-------------------|
| (1) | 100 grammes greater than the standard | i.e. 1880 grammes |
| (2) | 50       "       "       "       "    | i.e. 1830       " |
| (3) | Equal to the standard       "       " | i.e. 1780       " |
| (4) | 50 grammes less than the standard     | i.e. 1730       " |
| (5) | 100       "       "       "       "   | i.e. 1680       " |

The five weights may be designated by the letters A, B, C, D, E, and are to be presented in haphazard order. A single series consists of ten lifts and may be made up by putting two of each letter into a box, shuffling them, taking up the letters successively in haphazard order and presenting the corresponding values of the variable in each case. Each series is made up in this way.

**The Lifting of the Weights**—In lifting the weights the conditions must be kept as nearly constant as possible. A metronome is set going about 72 with a bell at every fourth beat. S. stands at one side of the revolving table, and E. opposite S. at the other side. E. places the standard weight in front of S., and the variable in front of himself. At the ringing of the bell, S. lifts the standard weight to the height of the cord, holds it up during the next two beats, and lowers it at the fourth beat. During the next four beats, E. revolves the table until the variable is directly in front of S., and on the next bell S. raises variable and lowers it on the fourth beat.

**Judgment of S.**—S. gives his estimate always in terms of the first weight lifted. The second weight is to be judged either greater than, equal to (or doubtful), or less than the first. Introspection of S. as to the method of judgment is taken down by E. as experiment proceeds.

As a revolving table is used, the space error is eliminated, but of course where a revolving table is not available, steps must be taken to eliminate the space error in the usual way. This will mean doubling the number of series by presenting the standard and variable at right and left respectively.

In order to calculate the time error, the order of presentation of standard and variable must change systematically throughout the experiment. In all, ten series should be given with the standard presented first, and ten series with the variable presented first, in the following order: standard first, standard second, standard second, standard first, standard first, standard second, standard second, etc., finishing up with a standard first. Subjects should change over after every series. A short practice series should precede each day's experiment.

**Results**—(a) Tabulate separately the judgments for the two time orders as follows:—

*Standard first.*

Variable.	Times judged greater than standard.	Times judged equal to standard.	Times judged less than standard.
A			
B			
C			
etc.			

*Standard second.*

Table as above, but note that in this case the judgment "less" means "greater" than standard, and the judgment "greater" means "less" than standard.

(b) Calculate threshold, after having converted the numbers in each column into percentages (1) graphically, (2) by the method of Interpolation,<sup>1</sup> using the following formula:—

$$\text{Upper Threshold} = \frac{D\beta(50 - \alpha) + D\alpha(\beta - 50)}{\beta - \alpha}$$

where  $D\beta$  is the value of the variable giving nearest percentage above 50,  $D\alpha$  the value giving the nearest percentage below 50, and  $\beta$  and  $\alpha$  the corresponding percentages of "greater" judgments.

$$\text{The True Threshold} = \frac{T_1 + T_2}{2},$$

$$\text{Time error} = \frac{T_1 - T_2}{2},$$

where  $T_1$  and  $T_2$  are the two thresholds obtained with the two time orders.

The Lower Threshold is calculated in the same way, using the "less" judgments.

<sup>1</sup> See Collins and Drever, p. 18.



## SYSTEMATIC EXPERIMENTS

### EXPERIMENT 14

#### *The Retinal Fields for Colour*

**Problem**—To map the retinal fields for the colours blue, yellow, red, and green. As a preliminary, to locate the blind spot and demonstrate its filling out.

**Apparatus and Material**—Blackboard with concentric circles representing angular distances at eye.<sup>1</sup> Adjustable rest for chin, fixing eye at 20 cm. from blackboard. Small rectangles of white, red, green, yellow, and blue paper, and square of white paper with black cross, also rectangle of magenta, in envelope. Black metal rod for holding paper.

**Procedure**—S. sits in front of blackboard, with chin on chin-rest and eye on level of centre of circular field, and, with left eye closed, fixates with the right the centre of field.

In preliminary experiment E. fixes white rectangle in holder, and places it in the centre of field, then while S. continues to fixate the centre, E. moves it slowly out till S. signifies that it has disappeared. E. records position in notebook. E. now begins further out—that is to the

<sup>1</sup> See Collins and Drever, Chap. I.

right—and moves inward till rectangle again disappears, marking point as before. These give the limits of the blind spot. E. now takes square with cross and places it so that the intersection of the arms of the cross is on blind spot as determined, and one arm horizontal, and records what S. sees. E. and S. change places.

In experiment proper E. takes one of the colours, S. being ignorant which, and places it in the marginal field. He moves it inwards by steps, recording the points at which S. first sees it, at which he first sees a colour, and what colour, at which he sees the true colour, and at which he sees the form clearly. This should be done with each colour, on the horizontal axis, the vertical axis in each direction, and midway between them above and below. Colours and lines should be taken in haphazard order. E. and S. should change after not more than two experiments.

**Results**—From his record E. should be able to map the field for each colour in the right retina. The magenta rectangle should be taken at the end, and the results of using this "mixed" colour recorded for horizontal axis alone. To facilitate the keeping of his record E. should tabulate his results for each line as below:—

Colour.	Angular distance at which S. sees.			
	Object in field. (1)	A colour and which. (2)	True colour. (3)	Form. (4)
Red Green etc.				

If no colour change takes place the same point is recorded in columns (2) and (3). The mapping of the field is based on column (3).

## EXPERIMENT 15

### *The Mapping of the Blind Spot*

**Problem**—To find the limits of the blind spot, to determine its outline, and to study visual phenomena associated with it.

**Apparatus and Material**—Chin and brow rest constructed so that S. looks straight down on a flat board beneath, when the head is in position. On the board is placed a sheet of white paper which fits it exactly, and which is fastened down by drawing pins. A long narrow strip of white cardboard (or stiff paper) edged with black at one end. Small strips of black, blue, yellow, red, and green paper. Holder with forked end for these.

**Preparation of Apparatus**—On the sheet of paper given for the experiment E. marks a point, which should be as accurately as possible the place where a person looking downwards with head in position for experiment would fixate his right eye in the primary position of the eye. A circle 2 mm. in diameter is drawn round this mark to make fixation easier. E. now draws a faint line through this mark parallel with the edge of the paper, and right through the entire length of the paper. This forms the primary line of exploration, for by experiment it has been found that this line cuts the blind spot. E. draws 10 mm. below this line another parallel to it. This is the secondary line of exploration, which has also been found by experiment to cut the blind spot.

**Procedure**—S. places head in position with brow and chin on their respective rests. The left eye remains closed throughout the experiment, while the right eye is kept steadily fixated on the spot with the circle round it. This is important and will require a little practice, for there is a tendency to move the eye. E. then moves the white strip with black end slowly and continuously along the primary line, starting from point of fixation, where, of course, the black tip will be clearly visible to S., until S. reports that the black end has disappeared from view.

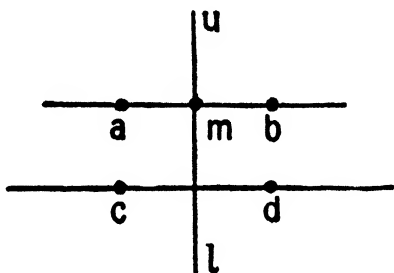


FIG 1.

E. notes the place at which this occurs, and continues from this point till the black tip reappears, again noting the point of reappearance. S. and E. should then change functions.

After this preliminary trial the first E. begins the experiment proper.

(1) E. repeats the procedure of the preliminary trial, exploring carefully the primary line, and marking the points on the paper where the last visible spot is seen, and the first visible spot appears. Repeat in exactly the same way with the secondary line. Suppose *a*, *b*, *c*, *d*, are the four points obtained in exploring the primary

and secondary lines respectively. Then measure each of these from the circle of fixation and find their lengths in millimeters. Their average will give the point *m* as measured from the centre of circle. By means of a protractor draw a line through *m* at right angles to *ab*. Call it *uml*. Again change subjects at this point in order not to fatigue the eye.

(2) The next step is to explore the line *uml*. E. draws the black-edged line slowly down the line *uml* and notes the last point where the black line is visible, and the first point of its reappearance. In this way the limits of *u* and *l* are found. Then measure *um* and *lm*. The six points, *ubdlca* are now joined together and form the area of the blind spot. Change subjects.

(3) Small strips of black and coloured paper, green, red, yellow, and blue (held in place by the holder with forked end) are now placed (1) vertically, (2) horizontally over the centre of the area of the blind spot, and S. records his impressions in each case. S., of course, still retains the same fixation point.

## EXPERIMENT 16

### *Colour Mixing*

**Problem**—To find the proportions of blue and yellow or of green and red required to produce a grey, and then to match this grey with a mixture of black and white.

**Apparatus and Material**—Motor or hand colour mixer. Large colour discs of blue, yellow, red, green. Small discs of black and white. Protractor. Screen of neutral grey for background.

**Procedure**—E. takes colour discs blue and yellow (or red and green), overlaps one colour with the other until equal proportions are showing, being careful to arrange that the overlapping edge is away from direction of rotation. He then sets the disc rotating on the colour wheel, the subject in the meantime looking away. When the rate of rotation is so rapid that flicker is abolished, E. says "now," S. looks at disc and decides whether and in what direction alteration must be made to get a colourless grey. If necessary a third colour may be added. When S. is satisfied that he has got grey, the sectors are measured with the protractor. The white and black discs are now placed in front, at first in equal proportions, and altered until the two greys match. If colour appears in the larger disc when compared with a true grey, that must be altered in the necessary direction. Sectors are then measured and an equation written.

Other S. repeats with the other two colours.

## EXPERIMENT 17

### *Colour Acuity*

**Problem**—To determine (1) the absolute threshold for colour and (2) the number of hues that can be distinguished between two adjacent spectral colours, as for example, red and orange.

**Apparatus and Material**—Colour mixer. Grey background. Colour discs, large and small as required.

**Procedure**—(1) *Absolute Threshold*—E. takes a large blue disc and a large black disc. He arranges the discs so that blue is distinctly visible to S. on rotation, then gradually reduces the amount of blue until S. ceases to see any blue. The sector of blue is then measured. E. now begins with an arrangement of discs such that blue is quite invisible to S. and increases the proportion of blue till it just becomes visible. He measures the sector of blue as before and for the threshold takes the mean of the two measurements. E. and S. change places and the experiment is repeated with the new S.

The experiment is then carried out in the same way with a white disc. If time allows it may be repeated with other colours.

(2) *Number of Distinguishable Hues*—Adjust two large discs of red and orange and two small discs of red and orange on the one colour mixer. To begin with, red alone is exposed in both discs. The smaller discs are then altered, orange being introduced until S. is just able to

distinguish a difference of hue between the smaller and the larger discs in rotation. The proportion of orange is then measured, the larger discs are adjusted to the same proportion and the experiment is repeated, the smaller discs being again altered until S. is just able to distinguish a difference of hue between them and the larger. E. continues in this way until both discs are orange.

By working in this way from colour to colour, the total number of distinguishable hues in the spectrum can be obtained approximately. S. and E. should consider why this only gives an approximation.



## EXPERIMENT 18

### *Colour Contrast*

#### *(a) Successive*

**Problem**—To study the phenomena of successive colour contrast—after-images.

**Apparatus and Material**—Neutral grey paper for top of table. W-shaped pieces of coloured paper. Rectangular pieces for backgrounds. The colours to be employed are : green on red, black on white, blue on yellow, orange on violet, and all *vice versa*.

**Procedure**—S. fixates a small mark on the grey paper of the table, and then E. places down the green paper on the red background in such a way that the spot marked on the centre of the W shall coincide with the spot on the grey paper. At the end of 15 seconds,<sup>1</sup> E. withdraws the coloured papers, S. continuing to look fixedly at the mark on the grey surface. S. should now report to E. the colours as they occur. S. should keep fixating the point until the sensations cease, and the number of appearances and disappearances should be recorded. The same procedure is followed with all the other colours, but S. and E. should interchange frequently, preferably after every experiment. If there is time the effect of projecting the after-image on the ceiling should be tried.

<sup>1</sup> Some subjects get better results with shorter time of fixation, others with longer.

Colour of Stimulus.	Colours in After-image.	Character of After-image.	Duration and Fluctuations.	Time of Appearance.
		Complete or Incomplete.		Whether immediately or after an interval.

*(b) Simultaneous*

**Problem**—To study the phenomena of simultaneous contrast.

**Apparatus and Material**—Six squares of paper, red, green, blue, yellow, black, and white. Small oblongs of paper, black, grey, and white. Cross of grey paper, and larger cross of black. Piece of tissue paper large enough to cover the squares. Neutral grey for table.

**Procedure**—E. takes the coloured squares one at a time, places the grey oblong in the centre, and covers with tissue paper. S., who in the meantime has been looking at the surface of the table, fixates on the word "now" the oblong, and reports on the colour which it has assumed, and any change in colour on long fixation.

This process is repeated with the black and the white oblongs respectively. Then the large cross is tried, and any difference in the effect produced is noted. These experiments are carried out with all the squares. E. and S. change functions frequently.

E. next takes the green and red squares, places them alongside one another with the edges in contact, and then places the grey cross so that half of it is on each colour, covering with tissue paper as before. The other complementaries are treated in the same way.

To demonstrate the effect of the tissue paper, E. should

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while it is in position on grey oblong outline the oblong, and S. should note the effect on the contrast colour.

Colour Stimulus.	Colour Contrast.	Effect of Prolonged Fixation.

## EXPERIMENT 19

### *Colour Blindness*

**Problem**—To detect the presence of colour blindness and to investigate its phenomena.

**Apparatus and Material**—This will vary according to the material at hand :

- (1) Colour mixer.
- (2) Stilling's Tables.<sup>1</sup>
- (3) The wool test.
- (4) Nagel Card test.

**Method**—(1) *Colour Mixing*—The colour experiments just described may all be used, colour mixing and colour contrast. The equations from colour blinds in colour mixing experiments vary considerably from those of normals. The colour blind can obtain a perfect colour equation using two colours only—e.g. red and green, whereas the normal colour visioner requires the addition of a third disc of colour. Further, the colour blind may match, according to his defect, a green disc with black and white, or a red disc with black and white. Below are typical colour blind equations. The student should rotate these on a colour mixer.

<sup>1</sup> The Ishihara Tests or the Collins-Drever Group Tests for Colour Blindness may be used.

$$360^{\circ} \text{ green} = 249^{\circ} \text{ black} + 111^{\circ} \text{ white}$$

$$360^{\circ} \text{ red} = 342^{\circ} \text{ black} + 18^{\circ} \text{ white}$$

$$360^{\circ} \text{ red} = 196^{\circ} \text{ green} + 164^{\circ} \text{ black}$$

$$162^{\circ} \text{ green} + 198^{\circ} \text{ red} = 279^{\circ} \text{ black} + 81^{\circ} \text{ white}$$

(2) If Stilling's Tables are available these should be used. S. is asked to tell what numbers he sees in each Table. It is also instructive to ask him the colours of the circles of both number and background.

(3) *The Wool Test*—The skeins should be spread out in good daylight illumination and in regular order. S. is handed one of the test skeins and is asked to pick out all those skeins of the same colour, irrespective of shade or tint. E. must be careful not to mention the name of the colour. Record should be made of those skeins accepted, and also of any which S. may reject. The test skeins to be used are (1) a bright red, (2) a bright green, (3) a pale pink, (4) a pale green, (5) a brown, (6) a magenta, (7) a pale blue. Confusions of colours will appear with these skeins according to the severity of the colour blindness.

(4) *Nagel Card Test*—Spread out the sixteen cards in Section A in good light. Then ask the S. to pick out those

(1) which contain red spots

(2) " " " " only

(3) " " green " "

(4) " " grey " "

When subjects select card 6, 11, or 12 in answer to question 1, there is evidence of colour blindness. As only 1 card is correct in the case of the other three questions, colour defect is indicated by the confusion made—either colour blindness or colour weakness. In Section B, S. is asked the colour of the circles in every case.

## EXPERIMENT 20

### *Colour Vision—Stereoscope*

*(After Langfeld and Allport)*

**Problem**—To study binocular inhibition and fusion.

**Apparatus and Material**—Stop watch ; stereoscope ; various pieces of cardboard as follows :—

- (a) piece of cardboard cut to fit holder of stereoscope ;  
all the other pieces of cardboard are squares  
half the size of the holder so that two of these  
can be placed in the holder together ;
- (b) two cards of white cardboard with diagonal in black  
ink drawn across each ;
- (c) two cards of white cardboard as above with diagonal  
across each, and in addition a line drawn across  
centre of card in black ink.
- (d) cards of the same size, but covered with coloured  
paper, one red, one green, one blue, one yellow,  
one black and one white.

**Procedure**—If stereoscopic cards are available, allow S. to practise with these by laying them one at a time in the holder of the stereoscope and adjusting same until a stereoscopic picture results. Once the distance of the holder from the eye has been found which gives the best result for S., this position should be kept approximately constant throughout.

(1) Place the large piece of cardboard in the holder, this acts as a support for the other smaller pieces. Then place cards *b* in the holder (squares with diagonals), one on the left-hand side, one on the right-hand side, edge to edge in the centre, so that the two diagonals meet at an angle (N.B. that there is no overlapping between the two cards, nor any gap between). S. then looks through stereoscope for one minute, timed by E. He says when left eye image is dominant, when right eye image is dominant, and when both diagonals intersect or fuse. E. should try to record approximate times for these. Change functions and repeat experiment with other subject.

(2) Next place cards *c* in the holder edge to edge, as before, with the diagonals meeting in a point; the line drawn across the cards will be vertical in the left-hand card and horizontal in the right-hand card. Observe as before for one minute. Note carefully also what takes place at the junction of the four lines. Change subjects.

(3) Place colours in pairs in the stereoscope (cards *d*).

Left-hand side	red	Right-hand side	green
„ „	blue	„ „	yellow
„ „	red	„ „	yellow
„ „	blue	„ „	green
„ „	black	„ „	white

Observe each pair for one minute and carefully record results. Note carefully the colour which emerges when any pair of colours fuse, and also note if any "lustre" effect appears when the black and white are used.

When both subjects have completed the experiment, try the effect of attempting to maintain in the case of any one pair of colours the dominancy of either, so preventing alternation or fusion.

**Results**—(1) Try to get a general indication of the rate of fusion and of inhibition.

(2) Compare results when complementary colours are used with results when disparate colours are used.

(3) Indicate the effects of voluntary control on the ordinary rates of inhibition and fusion.



## EXPERIMENT 21

### *Threshold for Pitch Discrimination*

(Complete Ascent and Descent)

**Problem**—To obtain the threshold for pitch discrimination (1) for a low note, (2) for a high note by the Method of Limits (complete ascent and descent).

**Apparatus and Material**—Spearman's dichord. Stopwatch.

**Method of Procedure**—E. adjusts the two strings of the dichord by moving the clamp of one of them until they both give a note of approximately equal pitch, and records the position on the scale. The one string is taken as standard and remains unchanged throughout the experiment, the other is the variable. S. is seated with back to dichord and is asked each time to compare the second note sounded with the first one and to say if the second is higher, equal or doubtful, or lower than the first. When E. strikes the notes he must be careful that he does so with equal intensity, and that he strikes the cords in approximately the same place each time.

**Preliminary Experiment**—To determine the rough threshold. This will also serve as a practice series.

E. places clamp on the variable so that it gives when struck a note distinctly higher than that yielded by the standard. E. says "ready" to S., then strikes standard

note, allows it to sound for a short time, damps it, then sounds variable, allows it to sound for the same time as standard, then damps it. S. now gives his judgment which ought to be higher in this case. E. moves the clamp down 5 mm., and repeats as before. The experiment is conducted in this way by always sounding the standard first and the variable second and decreasing by steps of 5 mm. at a time until S. gives the response "lower" twice in succession. One series is sufficient for a rough threshold. E. and S. should now change functions.

**Experiment Proper**—E. places clamp of variable at about 6 or 7 mm. above point where rough threshold was determined. The standard is sounded, then the variable as before, and the variable is decreased in regular steps of 1 mm. at a time until answer of S. changes from higher to equal, then to lower. The series is stopped whenever two consecutive replies of "lower" are given. Then an ascending series is given beginning at a place 4 or 5 mm. below where last series stopped and increasing in steps of 1 mm. at a time until two answers in succession of "higher" are given.

The complete experiment consists of five series beginning with a note higher than the standard (the descending) and five series beginning with a note lower than the standard (ascending) in each case passing through equality to the other side. E. should vary the starting point each time. Subjects should change over after every two series.

The threshold is obtained as follows: If we call the last value in the descending series where the variable is distinguished as higher than the standard, A, and the last value in the descending where the variable is judged equal to the standard, B, and the last value in the ascending series where the variable is judged less than the standard,

C, and the last value in the ascending series where the variable is judged equal to the standard, D., then the upper threshold, or  $U_1$ ,

$$= \frac{A + D}{2},$$

the lower threshold, or  $L_1$ ,

$$= \frac{B + C}{2}.$$

The experiment ought to be repeated in its entirety with the different time order, that is, with the variable presented first and the standard second.  $U_2$  and  $L_2$  are calculated in the same way as before.

The true threshold is then obtained by the average of  $U_1$  and  $U_2$  for the upper threshold, and of  $L_1$  and  $L_2$  for the lower threshold.

**Note**—The time error is obtained from the formula—

$$\frac{U_1 - U_2}{2} \text{ and } \frac{L_1 - L_2}{2}.$$

To obtain the threshold in vibration rate, E. places the clamp of variable at position on scale corresponding to true threshold. The two strings are set in vibration simultaneously and at the same time E. starts a stop-watch. Both E. and S. count the number of beats as long as audible, and record the time during which these beats are heard. Three counts should be taken, and the average number of beats per second gives the threshold in vibration rate.

*N.B.*—This same experiment may be carried out with Stern's variator or with tuning forks as described in Collins and Drever.

The experiment may be repeated using a higher note.

## EXPERIMENT 22

### *Threshold of Pitch Discrimination. Group Experiment.*

**Problem**—To obtain the threshold for pitch discrimination by a modified Method of Right and Wrong Cases.

**Apparatus**—*Tonmesser* or other apparatus capable of giving the requisite pitch differences.

**Method of Procedure**—E. arranges five comparison series of notes, in which pitch differences of 5*v*, 2*v*, 1*v*, .5*v* and 0*v* are presented. Each series consists of 20 presentations, arranged in haphazard order, in which each difference is presented four times, twice in each time order. At each presentation the subjects record whether the second note is "higher," "lower," or "same" as compared with the first. At each presentation E. says "ready," pauses about 2 seconds, and then presents the comparison notes. After each series is completed, E. goes over the series, giving the correct answer, and specifying the difference, in each case, and the subjects record these differences, and whether their answers are right or wrong.

**Treatment of Results**—The number of right answers for each interval is tabulated, the two time orders being on different tables, thus :—

Standard first.

Interval.	Right.	Wrong.

Standard second.

Interval.	Right.	Wrong.

The threshold is taken as that value which is discriminated in 50 per cent. of the trials (5 times out of 10). If no interval is discriminated exactly 5 times out of 10, the graphic method or the method of interpolation<sup>1</sup> may be employed to find the value required. The true threshold and the time error are found in the same way as in the case of the space error in Experiment 5.

$$\text{True threshold} = \frac{T_1 + T_2}{2},$$

$$\text{Time error} = \frac{T_1 - T_2}{2},$$

where  $T_1$  and  $T_2$  are the two thresholds obtained.

<sup>1</sup> See Collins and Drever, "Experimental Psychology," p. 18, and p. 33 above.

## EXPERIMENT 23

### *Auditory Acuity*

#### (Method of Limits)

**Problem**—To determine the absolute threshold for sound intensity.

**Apparatus**—Watch. String. Metre rod. Cotton wool.

**Method of Procedure**—S. plugs one ear with cotton wool and sits with eyes fixating a point directly in front of him.<sup>1</sup> E. stands at side of S. and holds watch at the unplugged ear where S. can distinctly hear it. Then E. gradually moves the watch away one inch at a time, until its ticking becomes inaudible to S. The distance is measured by means of the string. The one end is held by S. at his ear; at the other end is the watch, the appropriate distance being measured off each time by means of the metre rod. A descending series is carried out the same way. The watch is held at a distance such that its ticking is inaudible to S., then it is gradually brought nearer, one inch at a time, until S. can hear it.

The threshold is the average of the last point in ascending series where watch is audible to S., and last point in descending series where watch is inaudible to S.

Five series at least (descending and ascending) should be given.

Repeat with other ear.

<sup>1</sup> A better arrangement is for S. to sit with eyes closed, and head kept in constant position by a head rest.

## EXPERIMENT 24

### *Upper and Lower Limit of Tone*

**Problem**—To determine (1) upper limit of tone, (2) lower limit of tone.

**Apparatus**—Edelmann-Galton whistle. Giant tuning forks.

**Method of Procedure**—(1) *Upper Limit*—With the Galton whistle, using the Method of Limits, determine the point at which S. ceases to hear a note. (Ascending and descending series as usual.) Tables are supplied with the Edelmann-Galton whistle, giving vibration rate corresponding to definite scale readings.

(2) *Lower Limit*—Giant tuning forks are procurable with riders by means of which the vibration rate may be altered. Again, the Method of Limits should be employed in the usual way.

## EXPERIMENT 25

### *Cold Spots*

**Problem**—To map out the distribution of cold spots in a given region of the cutaneous surface.

**Apparatus and Material**—A brass cylinder ending at either end in a smooth point. A cork holder. Ice and water. Rubber stamp. Ink.

**Procedure**—The area to be explored is marked with stamp on back of left hand towards radial side between the base of thumb and base of forefinger. Area 20 mm. square, divided by cross lines into squares of 4 mm. side. The stamp is also applied to page of note-book to give map of area.

S. places hand on table with dorsal side up and fingers lightly closed. E. removes brass rod from pan of ice and water, dries and passes through cork. S. closes eyes. E. beginning with radial longitudinal line, moves point of rod slowly and steadily along line, keeping rod vertical. When a cold sensation is experienced, S. says "there." E. stops immediately, marks the spot with green ink on the map in the note-book, and gets from S. the information necessary for filling up the table below. He then resumes the movement of the rod till the next spot is found, changing the rod frequently for a fresh one from the ice and water. After finishing with the first line E. passes the rod along



the middle of the first space, then takes the second line, and so on. S. and E. change places after every two lines. A practice should be taken on the back of the right hand before beginning the experiment proper.

Position.	Sensa- tional Quality.	Localisa- tion.	Intensity.	Feeling.	Impulse.	Imagery.
	Sharp, etc.	Clear, Diffuse.	1, 2, 3.	Pl., Upl., Indiffer- ent.		

Position is easiest recorded as follows: Number the lines to be explored 1, 2, 3, etc., and the spaces 1a, 2a, 3a, etc. Each small square is 4 mm., so if a cold spot is on line 1, 4 mm. along, it may be written 1-4 and so on. The first figure refers to the line, the second to the number of millimetres along the line.

(2) *Heat Spots*—The procedure is exactly as before and the same area is explored. This time the rods are immersed in a bath of water heated to a temperature between 45°-50° C. A different colour of ink may be used for marking the spots in the map in the note-book.

(3) *Touch Spots*—The same area on the back of left hand is used as before. E. by means of a magnifying glass detects the hairs on the surface to be investigated. The points of emergence of the hairs are marked, and their positions recorded on a map in note-book. The hairs are then cut off close to the skin. The stimulation is by means of a hair mounted on a rod and at right angles to it. In exploring the surface, it is important that the hair is kept perpendicular to surface of skin. The area is explored by a series of regular touches timed by the beat of a metronome which is set at 75. The rod is lowered

on the one beat and raised at the next and the touches are at a distance of 1 mm. apart.

(4) *Pain Spots*—The stimulation is by a needle or a bristle mounted on a rod. It is important that the needle should not pierce the skin. The procedure is precisely the same as in the case of the touch spots.

## EXPERIMENT 26

### *The Localization of Sounds*

**Problem**—To determine the accuracy of localization of sounds at different positions in the horizontal plane, and the nature of the errors made in the coronal and sagittal planes respectively, and from the results to deduce the basis of sound localization.

**Apparatus and Material**—Cane. Snapper. Chalk circle.

**Procedure**—S. sits in stool in middle of circle with eyes closed and head kept in as steady a position as possible. E. holds the cane vertically, his thumb on the top end, and produces the sound to be localized with the snapper on the top of the thumb. Using the Method of Limits he determines the threshold for localization in front, behind, to right, and to left. In each case he begins with a descending series. After giving the signal "ready" he makes the sound at the zero position, then moves the cane to  $30^{\circ}$  away from that and gives sound again, moving inwards by  $5^{\circ}$  till S. says "same" twice in succession. He then takes an ascending series beginning nearer the standard. Each series should be repeated three times. Eight thresholds in all are to be determined. S. and E. change after every threshold.

In the second part of the experiment localization is

tested in the sagittal (the median) plane, and coronal plane (the vertical plane passing through both ears). E. begins with sagittal. E. takes seven positions in plane at  $45^\circ$  from one another, and numbers these 1 to 7. He makes the sound at each of these positions five times in irregular order, recording the location given by S. each time.

Attempt to deduce from results the basis of localization.

If a sound perimeter is available much more accurate work can be done.

## EXPERIMENT 27

### *Fluctuations of Attention*

**Problem**—To record and measure by means of the appearance and disappearance of a minimal stimulus the fluctuations of attention.

**Apparatus and Material**—Masson disc on motor. Black screen with slit  $\frac{3}{4}$  to 1 inch wide. Kymograph with slow movement (one rotation in 3 to 4 minutes). Time marker ( $\frac{1}{5}$  or  $\frac{1}{2}$  seconds). Tambour with marking lever, rubber tubing, and pressure capsule or bulb.

**Procedure**—(1) To smoke the drum fasten the paper supplied round the drum, gumming down the edge in such a way that the raised edge moves away from the direction of the drum's rotation. Rotate drum over a smoky flame (from camphor, or coal gas passing through benzene) until paper is uniformly black all over.

(2) To get the record on the drum bring the point of the marking lever of the tambour and the lever of the time marker, the one vertically above the other, into light contact with the smoked surface, the levers being placed tangentially to the drum and pointing towards the direction in which the drum is rotating.

(3) E. familiarizes himself with the working of the apparatus, the starting of the kymograph, etc. S. familiarizes himself similarly with his task. First of all he makes sure that he sees the grey rings when the Masson disc is rotated. Then he fixates the faintest and farthest-out ring he can see, and notes that it seems to disappear

at intervals. It is the appearances and disappearances that must be recorded.

E. now places the dark screen in front of the disc, with the slit at such a level, and in such a position, that it exposes a portion of the disc from centre to circumference. The lighting should be so arranged that no shadows fall on the portion of the disc exposed. The disc is rotated, and S. fixates the faintest ring he can see. The pressure bulb is placed in his hand, and he is instructed to press the bulb lightly as long as he sees the ring, to release all pressure when it disappears, to press again when it reappears, and so on. When S. has obtained some practice at this, and the fluctuations are appearing with some regularity, E. starts the drum, taking a record during one revolution, and stopping the drum again at the starting point.

S. and E. change places and the same procedure is repeated with the new S. A second record should be obtained in the same way from both subjects.

(4) Before removing the smoked paper from the drum all necessary information concerning the records should be marked on it—date, initials of subjects, unit of time, etc. It is then cut down with a knife tangentially at the join of the paper, care being taken to keep it from falling or brushing against anything as it comes away from the drum, which if possible should be removed from the stand. The paper must then be passed through a dish of varnish, the smoked side being kept up. The record, after it is dry, can be handled and examined at will. Each E. should examine the records of his S., determining from the time record the times during which the circle was seen by S. and the times during which it was invisible. The average gives the average time of fluctuation.

## EXPERIMENT 28

### *Division of Attention*

**Problem**—To investigate the effect of divided attention on the performance of a simple piece of work.

**Apparatus**—McDougall's disc apparatus. Sheet of sentences to be completed. Sheet with fixation point. Stop-watch.

(Note—This apparatus consists of three upright brass rods 12 inches in height. On the centre rod are threaded 15 black and 15 white wooden discs.)

**Procedure**—E. arranges discs in haphazard order on central rod and places sheet with fixation point behind the apparatus and at the level of S.'s eyes. S. is instructed to keep the eye fixed on the fixation point and thread the white discs on the right-hand rod, the black discs on the left-hand rod, as quickly as he can, using one hand only, lifting one disc at a time and not stopping to correct any error. E. records the time by means of the stop-watch. S. and E. at this stage change functions.

In the second part of the experiment, the task of threading the discs is performed as before, but the sheet with the sentences to be completed is substituted for the sheet with the fixation point, and S. is instructed to read the sentences aloud, filling in the blanks simultaneously with the threading. The time is again recorded with the stop-watch. E. and S. change functions.

**Tabulation of Results**—For every error made in threading discs, add the average time taken for threading each disc.

Time (Thread Discs).	Time (Discs and Sentences).	Percentage Increase.	Number of Sentences Read.



## EXPERIMENT 29

*Attention—Attitude or Set.*

*(After Foster)*

**Problem**—To study the influence of set, or the influence of directing the attention in a specific direction.

**Apparatus and Material**—Stop-watch. Two series of anagrams, ten in series, and each anagram composed of five letters, the anagrams to be arranged in columns.

Series 1 is devised without any particular set, the anagrams referring to objects in general, e.g. NOEMY (money), SIMCU (music).

Series 2 is devised with a definite set, and the anagrams all refer to household goods. LBATE (table), KOCCL (clock).

Piece of grey paper with aperture sufficient to reveal one anagram at a time.

**Procedure**—E. places sheet containing anagrams underneath cover sheet of grey paper so that the first anagram appears at the aperture. E. tells S. that the first set of anagrams is general in nature, and that there is no definite set of the attention. E. says "ready" to S., then "now." At the word "now," the first anagram is exposed, and the stop-watch set in action. S. has to

discover mentally without using pencil and paper, what word the five letters of the anagram will make if they are arranged in proper order. When he discovers what the word is, he indicates this to E. who stops the watch and records response and time. After the ten anagrams of Series 1 have been completed in this way, E. and S. change functions, using, of course, a different set of anagrams.

In part two of the experiment, Series 2 is used. It is explained to S. that the anagrams in this series have been drawn up with reference to household goods, and that the attention is to be definitely set in this direction. The responses and times are recorded as before, and then functions are changed again. If in this section S. finds a word from the anagrams which has no reference to household goods, it is accepted as correct.

In both series, a time limit of 30 seconds is advisable. If S. is unable to discover what the word is in that time, record a fault.

**Results**—(1) Find the median time for the responses in Series 1. To do this, arrange the ten times recorded in order of time taken, from the longest time which will be the faults at 30 seconds, to the shortest time. The median of a series of ten is the average of the fifth and sixth in the series.

(2) Find the median of the times for the responses in Series 2.

(3) The times in Series 2 with definite set should be much shorter than in Series 1 with indefinite set. Usually times for indefinite set are about 2.5 times longer than with definite set. Compare this proportion with the results obtained from your S.

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## A

### Series 1

1. P   R   P   E   A
2. I   D   E   U   G
3. T   G   I   H   L
4. E   T   H   E   S
5. C   A   R   H   M
6. S   P   M   A   T
7. O   E   V   L   G
8. I   R   D   O   A
9. T   W   A   H   E
10. I   R   C   G   A

### Series 2

1. R   C   I   A   H
2. I   N   P   O   A
3. R   A   C   E   M
4. U   B   H   R   S
5. H   C   P   R   O
6. O   T   L   O   S
7. C   T   A   H   M
8. R   U   G   S   A
9. N   L   I   D   B
10. F   E   N   I   K

## B

### Series 1

1. A   W   R   E   T
2. N   R   O   B   I
3. N   D   C   A   E
4. O   T   R   O   M
5. S   S   G   A   L
6. W   H   C   A   T
7. E   I   P   Z   R
8. T   H   W   S   I
9. R   F   T   I   U
10. E   S   U   H   O

### Series 2

1. A   P   A   T   L
2. D   R   E   B   A
3. P   O   S   N   O
4. O   C   C   U   H
5. R   O   F   U   L
6. E   S   V   O   T
7. L   O   E   T   W
8. T   L   H   O   C
9. O   A   C   C   O
10. D   E   A   S   H

## EXPERIMENT 30

### *Span of Apprehension*

**Problem**—To determine how many letters can be grasped in one act of attention (*a*) when the letters do not, and (*b*) when the letters do, form a word.

**Apparatus and Material**—Simple fall tachistoscope. Blank cards.

**Procedure**—(1) Preparation of the cards: Each E. will prepare three sets of cards with two letters, three letters, four letters, five letters, six letters, respectively, in block capitals; also three sets of cards with words of five letters, six letters, seven letters, and so on up to twelve or fourteen letters in block capitals.

(2) Conduct of experiment: E. sets the shutter so as to close the aperture, and places a card with two letters in the slots. S. sits straight in front of the tachistoscope. When E. says "ready" S. fixates the fixation point which E. has placed on the front of the shutter opposite where the aperture will be exposed. After about two seconds have elapsed E. releases the shutter, and S. attempts to read the letters exposed. If he is successful E. passes on to a card of three letters, and so on till the subject fails to read the letters exposed. As soon as S. fails to read the letters accurately E. takes a second card with the same number of letters. If S. fails with the second card, E. exposes a third card with

the same number of letters. The span of apprehension is given by the highest number of letters read after not more than three chances.

S. and E. now change over and repeat the experiment with the nonsense letter series of the other E. When this part of the experiment is finished S. and E. change functions once more, and work through the words in precisely the same way, beginning with words of five letters. It may be that S. will be able to read the words containing the highest number of letters. In that case E. may continue to increase the length of the words exposed, if there is time, until the limit of S.'s apprehension is obtained.

Letters Exposed.	Letters Read.	No. of Letters.	Remarks.

**Note**—Other types of material may also be used, e.g. crosses, numbers, short sentences, etc.

## EXPERIMENT 31

### *Reproduction of Time Intervals*

**Problem**—To study the accuracy of reproduction of time intervals of different lengths.

**Apparatus and Materials**—Two reaction keys. Sound hammer or telegraph sounder. Marker magnet. Jacquet chronograph or other means of recording time on drum. Two three-way keys. Stop-watch. Smoked drum.

**Procedure**—Connect up as shown in Fig. 2.

The marker magnet should be in contact with smoked drum exactly over time-marker lever. S. should if possible be in a different room from registering apparatus. Failing that the registering apparatus should be screened off.

**First Method**—E. taps the reaction key twice with a definite interval of time between the taps, and S. gives the third tap the same interval after the second as the second is after the first.

**Second Method**—E. taps reaction key twice to mark the beginning and end of a time interval. A definite time is allowed to elapse, and then E. says "now," and S. taps twice so as to mark the limits of what appears to him an equal interval of time.

If there is time both methods should be employed, and the time between stimulus and reproduction in the second

method should also be varied. The description which follows is intended to apply, *mutatis mutandis*, to either method.

Measuring time by the stop-watch, E. should give intervals of approximately 1 second, 2 seconds, 3 seconds, 5 seconds, 6 seconds, 8 seconds. In an hour's experiment each should be given twice in haphazard order, making twelve reproductions for each S. A constant time—say

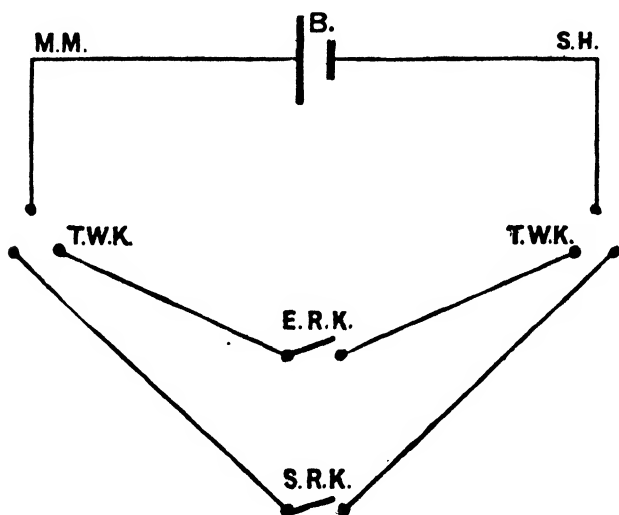


FIG. 2.—Circuit for reproduction of time intervals.

B. Battery; SH. Sound Hammer; TWK. Three-way Key; MM. Marker Magnet; ERK. E.'s Reaction Key; SRK. S.'s Reaction Key.

1 minute—should be allowed to elapse between one reproduction and the next. This time may be utilized for giving introspection.

## EXPERIMENT 32

### *The Estimation of Time Intervals*

**Problem**—To determine the differential threshold in the estimation of time intervals of short duration.

**Apparatus and Material**—Time wheel. Sound hammer. Two-volt battery. Switch. Wiring.

**Procedure**—The arm of the time wheel should rotate at the rate of about one revolution in 5 seconds. At this rate 72 on the scale will represent 1 second. Intervals of

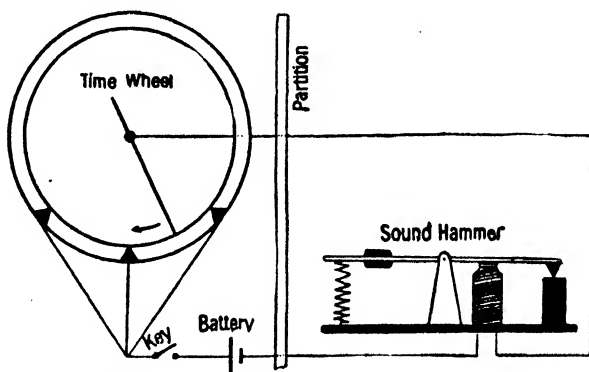


FIG. 3 —Schematic representation of time wheel and connections for estimation of time intervals.

$\frac{3}{4}$  second, 1 second,  $1\frac{1}{2}$  seconds, 2 seconds should be used. S. should be seated in another room in which the sound hammer is also placed. Connect as shown in diagram.



The arm of the time wheel should be allowed to reach its full rate of rotation before the sound hammer circuit is closed. About 2 seconds before each estimate E. will call out "ready." The Method of Limits with complete ascent and descent should be employed, and both orders of presentation—standard first and standard second. S. should respond in each case by saying of the second interval "greater," "equal," or "less," as compared with the first, but E. will always keep the record in terms of the standard. S. should write his introspection as the experiment proceeds, emphasizing his method of judging the length of an interval.

## EXPERIMENT 33

### *Reaction Time (Simple Method)*

**Problem**—To determine the time S. takes to respond to a visual stimulus.

**Apparatus and Material**—Kymograph. Exposure apparatus with reaction key attached.<sup>1</sup> Marker magnet. The kymograph drum should be already smoked and the time record in hundredths of a second marked on it by means of a tuning fork. Coloured cards to fit exposure apparatus.

**Procedure**—E. places lever of marker magnet in position for recording on the drum. He then raises shutter and places one of the coloured cards in the slot behind the aperture. S. places his finger on the reaction key, and the drum is set in motion by E. E. says "ready" and after an interval of about 2 seconds, pushes down the shutter. S., on seeing the colour, responds by releasing the key. (S. should take care not to respond to the sound of the shutter.) After a practice of three trials, repeat ten times for experiment proper. The average of this series gives the natural reaction time for S. Take a similar series after instructing S. to concentrate attention on the stimulus. This will give sensorial reaction time. Repeat

<sup>1</sup> This is a simple exposure apparatus so constructed that the pushing down of the shutter makes the circuit, and the raising of the finger from the reaction key breaks the circuit.

with instruction to concentrate attention on rapidity of response. This will give muscular reaction time. Practice should precede each series, and S. and E. should change functions after each series.

S.'s discrimination time may be obtained by arranging a series of six colours, each presented five times in haphazard order and instructing S. to react only to one of these colours.

Records are varnished in the usual way, and reaction times measured by means of the time record.

For reaction time experiment using the Hipp chronoscope, consult Myers's "Experimental Psychology," Part II.

## EXPERIMENT 34

### *The Conditioned Reflex*

*(This experiment is an illustration of the conditioned reflex method, rather than a systematic and complete experiment.)*

**Problem**—To study the establishing of a conditioned motor reflex.

**Apparatus**—Board for hand with receiving tambour as described and illustrated in J. B. Watson's "Psychology from the Standpoint of a Behaviourist," p. 33. Electric bell. Inductarium. Two double marker magnets. Recording tambour. Kymograph. 3-way key. Reaction key. Screen between S. and E.

**Procedure**—Connect circuit as in sketch, and connect receiving tambour to recording tambour. S. places hand on metal plate with middle finger in contact with T-piece. The saddle of the recording tambour is brought down on the middle finger, so that the withdrawal of the finger as the result of an electric shock from the secondary coil of the inductarium moves the lever of the recording tambour on the drum. Trial should be made to determine the appropriate intensity of shock. E. first sounds bell alone to see if it will produce a response. (Normally, no response is produced.) E. starts kymograph, then sounds bell and gives shock simultaneously five or six

times, and then tests again with bell alone. He repeats this procedure until the response is elicited with bell alone. Each time the bell fails to elicit a response, E. immediately inserts plug and gives electric shock, thus

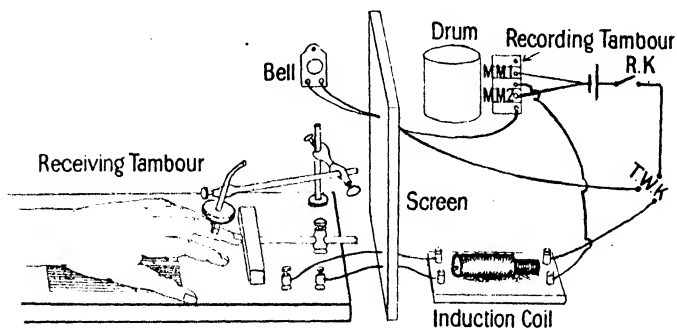


FIG. 4.—Schematic representation of connections for conditioned reflex.

T.W.K. = Three-way key. R.K. = Reaction key. M.M. 1-2 = Marker magnets.

compelling the response. When the response is elicited by the bell alone twice or thrice in succession, we may consider the reflex as partially established, and the experiment may be stopped at this stage.

## EXPERIMENT 35

### *Muscular Work—Ergograph*

**Problem**—To study the difference in amount of work done with different distributions of work and rest periods.

**Apparatus and Material**—Mosso's or Kraepelin's ergograph. Kymograph. Metronome. The experiment described below is with Mosso's ergograph.

**Procedure**—(1) The work to be done is 60 lifts, one every 2 seconds and the total rest period 60 minutes. The work and rest are to be distributed differently on different days: thus 30 lifts, 60 minutes' rest, 30 lifts: 20 lifts, 30 minutes' rest, 20 lifts, 30 minutes' rest, 20 lifts: 15 lifts, 20 minutes' rest, 15 lifts, 20 minutes' rest, 15 lifts, 20 minutes' rest, 15 lifts: and so on. According to the number of different distributions chosen the experiment will extend over 2 days, 3 days, 4 days, etc., in addition to a first day devoted to finding a suitable weight and to practice.

(2) A suitable weight must first be determined for each subject. This is a weight of such a magnitude that S. can lift it 30 times successively, but not without a very definite degree of muscular fatigue being shown. The weight must be determined by trial. S. places his arm in the arm rest, in which it is clamped, forefinger and third finger are inserted into the finger caps as far as they will go, and the loop attached to the weight is placed on the

terminal joint of the middle finger. In the state of extension the finger should be as nearly straight as possible so that in flexing the finger the weight is lifted through as large a distance as possible.<sup>1</sup> S. must now practice keeping time with the beat of the metronome. The metronome beats seconds with a bell at every second beat. S. lifts on the bell and lowers on the next beat, each lift thus taking 2 seconds. No experiment can be done on the first day, but the subjects should both be in a position to start right away on the second day. The experiment described below is one extending over 2 days.

(3) On the first day S. does 30 lifts taking 60 minutes' rest and then does the other 30 lifts. E. notes the position of the travelling scale of the ergograph at the beginning of each series of lifts and then again at the end of each series. The difference shows the height through which the weight has been lifted in the series. No practice is allowed before the series begins. E. says "ready" and then "go!" S. lifts on the first bell thereafter, and keeps lifting and lowering in time with the metronome till E. who has counted the lifts says "stop." The other S. does 15 lifts four times, with 20 minutes' rest between each series, in the same way.

On the second day the first S. does the 15 series, and the second S. the 30 series.

On each day the drum records are varnished in the usual way.

	Weight.	Height. 1st Series.	Height. 2nd Series.	Height. 3rd Series.	Height. 4th Series.	Total Height.
1st Day .						
2nd Day .						

<sup>1</sup> See frontispiece.

In addition E. should compare the amount of work done in the first 15 lifts of the second 30 with the amount done in the third 15 lifts in the other distribution.

By means of an additional's day's experiment, the effect of incentives may be studied. Trace a line with lever on the drum at the level of the largest contraction made by S. S. then lifts the weight 30 times watching the lever and attempting to reach the line each time. Compare the total work done under these conditions with previous result when 30 lifts were done.



## EXPERIMENT 36

### *Tapping Experiment*

**Problem**—To study the motor efficiency of an individual by means of rate of tapping and ability to maintain the rate.

**Apparatus**—McDougall's tapping board. This consists of four Veeder counters mounted on a wooden base, and tapping rod with rubber end.

**Procedure**—E. reads and records the numbers on the four counters. S. places rod on side rest, at the word "ready!" When E. says "go!" S. proceeds to tap as quickly as possible on projecting plate of the first counter. At the end of 15 seconds, E. says "change," whereupon S. changes to second counter continuing tapping, and so on to third and fourth counters. E. thus has a record of 1 minute's tapping by S. divided into four periods of 15 seconds each; when he has taken the new readings of the counters and subtracted, E. should tabulate thus:—

	No. of Taps.
1st 15 seconds.	
2nd 15 seconds.	
3rd 15 seconds.	
4th 15 seconds.	

**Treatment of Results**—Calculate:—

- (1) Difference between first  $\frac{1}{2}$  minute and second  $\frac{1}{2}$  minute (plus or minus).
- (2) Percentage difference (plus or minus).

## EXPERIMENT 37

### *The Mental Work Curve*

**Problem**—To study the variations in the efficiency of mental work at different stages in a period of continuous mental work.

**Material and Apparatus**—Book with digits in columns (Kraepelin's *Rechenheft*). Stop-watch or stop-clock.

**Procedure**—S. will do 30 minutes' work adding digits in threes—the 1st, 2nd, 3rd, then 2nd, 3rd, 4th, then 3rd, 4th, 5th, and so on—and placing the sum opposite the third digit to the left in every case. When S. comes to the bottom of a column, he should go on to the top of the next column, without attempting to carry over digits from one column to the other.

E. says "ready" and then "go!" starting the stop-watch or clock. At the end of every minute he says "one minute," "two minutes," "three minutes," and so on, and S. makes a cross at the last sum written. At the end of 30 minutes, E. and S. change places and repeat the experiment with the new S.

When both S.'s have finished, they should each go over the work done, counting the number of digits added in each minute, and plotting a curve showing this.

If errors are to be taken into account, the additions should be verified and three deducted for each error from

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the work of each minute in which an error occurred. The errors may also be plotted separately.

To get a smoothed curve, take for each minute the average of the minute before, that minute, and the minute after.

## EXPERIMENT 38

### *The Measurement of Fatiguability.*

**Problem**—To measure the fatiguability of an individual.

**Apparatus and Material**—As in Experiment 37.

**Method of Procedure**—The experiment should be extended over four days. On the first day S. adds digits in threes, as in Experiment 37, for 10 minutes, then rests 5 minutes, and then adds digits, as before, for another 10 minutes. E. and S. then change places and the new S. carries out the same work under the same conditions. On the second day the subjects add digits for 10 minutes, rest for 10 minutes, and then add digits for another 10 minutes. On the third day the subjects add digits for 10 minutes, rest for 15 minutes, and add digits for another 10 minutes. On the fourth day the subjects add digits for 20 minutes without rest, the point reached at the end of the first 10 minutes being marked by a cross.

**Treatment of Results**—Count the number of digits added by S. in each 10-minute period, and tabulate :—

	First Period.	Second Period.	Gain in Second Period.
1st day . .			
2nd day . .			
3rd day . .			
4th day . .			

Calculate the percentage improvement in the 2nd period for each of the first three days. Take the highest percentage, and assuming that this shows the "most favourable pause" add this percentage to the work done in the *first* 10 minutes of the fourth day. The difference between this total, and the actual work done in the *second* 10 minutes of the fourth day, is taken as the falling off due to fatigue. The coefficient of fatiguability is this difference as a percentage of the work done in the *first* 10 minutes of the fourth day.

## EXPERIMENT 39

### *Ash's Reversible-Perspective Test*

**Problem**—To test for fatigue by noting the rate of voluntary reversal of a reversible-perspective figure.

**Apparatus**—Figure of cube as in sketch. Kymograph.

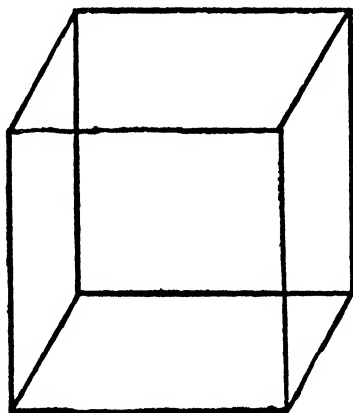


FIG. 5.—Reversible Cube.

Tambour and bulb as in fluctuations of attention experiment. Time marker. Jacquet chronograph or other arrangement giving seconds.

**Procedure**—S. first practises reversing the figure until facility and regularity of reversal are acquired. The practice should be done with the pressure bulb in his

hand, and he should press the bulb for one perspective, and release it for the other. In the experiment proper :—

(1) E. first gets a record on the smoked drum of S.'s normal rate of reversal. The record need not extend over more than 30 seconds.

(2) S. performs mental additions, adding continuously 8, 7, 6, 5, 8, 7, 6, 5, etc., to numbers of two digits called out by E., a new number being called out every minute for 30 minutes. At the end of the 30 minutes, another record of rate of reversal is taken on the smoked drum.

**Treatment of Results**—The average time of reversal before work and the average time of reversal after work should be calculated from the records on the drum.

## EXPERIMENT 40

### *The "Aussage" Experiment*

**Problem**—To study the accuracy and reliability of observation and report, and incidentally to estimate suggestibility.

**Material**—A suitable picture ("North American Indians" or "The Haymakers" in W. & A. K. Johnston's series of wall pictures for object lessons, or any picture of similar character may be used). Stop-watch. A series of from 20 to 30 questions of different types, including 6 to 8 suggestive questions.

**Procedure**—The experiment should be conducted as a group experiment:—

1. E. will beforehand have selected the picture to be used and prepared the series of questions for the cross-examination. A specimen series of questions is appended below.

2. Report. The picture is exposed for 30 seconds, the subjects being instructed to observe it carefully, since they will be asked to write a description of it after it is withdrawn. After the expiry of the 30 seconds the picture is removed, and the subjects told to write as detailed an account as they can of everything they have seen in the picture. Fifteen minutes may be allowed for the writing of this report with adult subjects. It is important that



the subjects should not compare notes while writing the report.

3. Cross-examination. Before beginning to read the questions E. ought to caution the subjects not to let any expression of any sort escape when they hear a question. The questions should be read in level, even tone, the subjects writing the answers and numbering them.

4. After the cross-examination is finished the picture is re-exposed in order that the subjects may check the statements they have made. The following quantitative results should be worked out :—

(a) Coefficient of Fidelity of Report, which is given by :—

$$1 - \frac{\text{number of erroneous statements}}{\text{total number of statements made}}, \text{ as a percentage.}$$

(b) Coefficient of Reliability of Testimony, which is given by :—

$$1 - \frac{\text{number of erroneous answers}}{\text{total number of questions answered}}, \text{ as a percentage,}$$

(c) Coefficient of Suggestibility, which is given by :—

$$\frac{\text{number of suggestions accepted}}{\text{number of suggestive questions}}, \text{ as a percentage.}$$

*Specimen Series of Questions on "The Haymakers"*

1. How many persons are in the picture ?
2. How many animals ?
3. What is the man in the extreme right of the picture holding in his hand ?
4. How many of the horses are turned towards the left ?
5. Is the gate into the next field open or shut ?
6. Is the woman's blouse blue or yellow ?

7. Which of the horses is grey ?
8. Is there a dog in the picture ?
9. Is he sitting or standing ?
10. Has the man on the hay waggon in the foreground  
a beard ?
11. Has the man on the rake ?
12. Is there a pail under the umbrella ?
13. In which direction is the woman facing ?
14. What has the little girl on her head ?
15. Did you see the hole in the umbrella ?
16. Which of the little girl's hands is laid on the head  
of the dog ?
18. What is the colour of the wheels of the rake ?
19. What is the colour of the little girl's pinafore ?
20. Is the ribbon on the woman's hat blue or green ?

## EXPERIMENT 41

### *Illusion of Warmth. (After Seashore and Whipple)*

**Problem**—To test the suggestibility of S. by Seashore's "warmth illusion" apparatus.

**Apparatus and Material**—Box with lamps, lamp switch (LS), and secret switch (SS). Resistance wire on rubber core. Stop-watch. Arrange apparatus as in diagram.

**Procedure**—(1) E. instructs S. to hold the resistance wire between his thumb and forefinger, and to say "now" the moment he feels warmth in the wire. In the first three trials at least there ought to be objective warmth, and the arrangement should be such that the wire is perceptibly heated in about 10 seconds. After these preliminary trials with objective warmth, E. should switch out the resistance wire by means of the silent and secret switch SS. and take five further experiments without objective warmth. In each case E. says "ready," ostentatiously switches on the lights by means of switch LS, and starts the stop-watch. He records the time until S. says "now." After this first series E. and S. should change functions.

2. In a second series 20 trials should be taken, 10 with and 10 without objective warmth, arranged in haphazard order. This is the real experiment, so far as it can be carried out with an S. "in the know."

In all cases sufficient time—say 2 minutes—should be allowed between the trials for the resistance wire to cool, and it is advisable to keep this time constant.

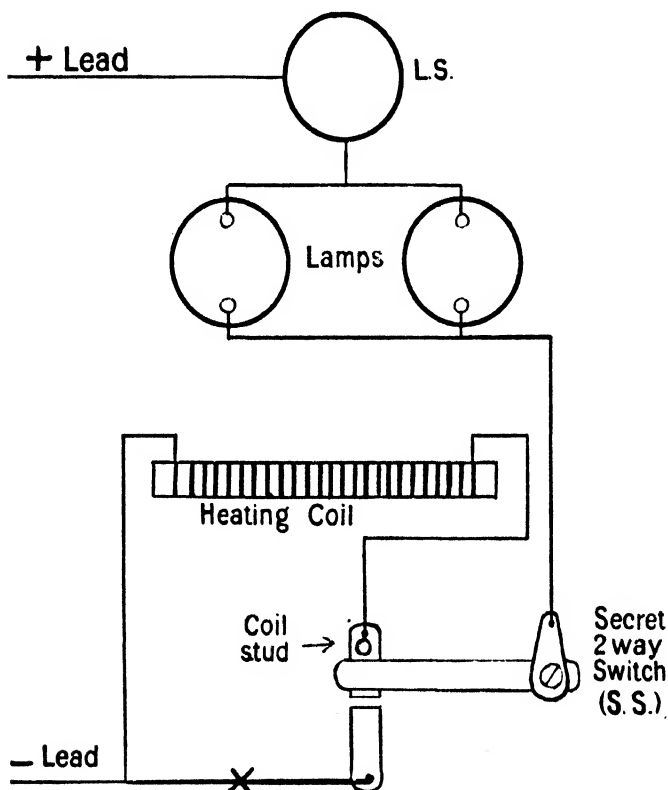


FIG. 6.—Schema showing connections of warmth tester balance coil inserted inside box at X to make lights equal.

The number of times the suggestion of warmth is taken, and the average time from switching on the lights to S.'s "now" should be recorded.

## EXPERIMENT 42

### *The Measurement of Suggestibility*

*(Hull's Postural Method)*

**Problem**—To record and measure the suggestibility of S. by Hull's "postural method."

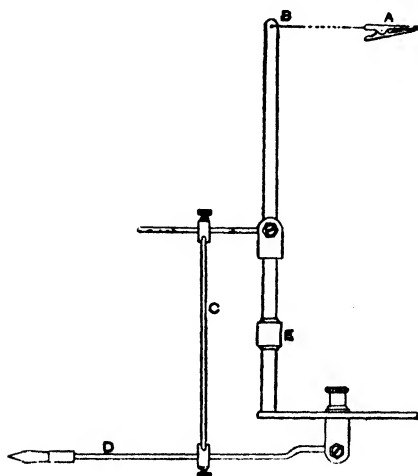


FIG. 7.—A. Clip for fastening to subject's shoulder. B. Long arm of right-angled lever. C. Connecting band. D. Marking lever. E. Bracket for attaching to retort stand.

**Apparatus and Material**—Smoked drum. Contact metronome or clock. Two time markers. Signalling

key. Special recording lever. The recording lever (see Fig. 7) consists of a right-angled lever with a long arm and a short arm. To the long arm (B) a thread is attached, about 4 feet long, with a hook or clip (A) at the other end. The short arm is connected by an adjustable metal band (C) to a brass lever (D) with a marking point, the fulcrum of this lever being also adjustable.

**Method of Procedure**—As a preliminary, S., without being attached to the recording apparatus, but with his back to it, stands, with his heels about 6 inches apart, his hands by his sides, and his eyes closed. E. says: "See how steadily you can stand. You are swaying forward. You can't help it. Forward still more. More yet." E. carefully observes S.'s movements, while the suggestions are being given, and notes the extent of his movements with a view to the proper adjustment of the recording apparatus. The clip or hook on the end of the thread is now attached behind S.'s right shoulder, as far as possible without his knowledge. The marking lever is brought in contact with the drum tangentially in such a position that the thread is just tight when the marking lever is horizontal. The two marker magnets are also adjusted, one over the other and exactly above the marking point of the recording lever, the upper marker magnet in circuit with the signalling key, and the lower with the contact metronome or clock, giving a contact at each second. A record of the swaying of S. is taken for 1 minute without suggestion. E. then begins suggestion as before: "You are swaying forward. You can't help it. Forward still more. Now you are going backwards. Still more backwards." E. pauses for 2 seconds between each suggestion, and goes on giving such suggestions for 2 minutes. E. presses the signalling key at

the beginning and end of each suggestion period. After 1 minute without suggestion, E. again gives suggestions for 2 minutes. E. should vary his suggestions according to the direction of sway that S. is actually showing, and should be ready to stretch out his hand to prevent S. falling either forwards or backwards. The experiment is repeated after E. and S. have changed places.

**Treatment of Results**—From the smoked drum record, after it has been varnished and dried, E. determines the time elapsing between the giving of a suggestion and the response, the direction of the response, the amount of the response as compared with the normal amount of swaying without suggestion.

## EXPERIMENT 43

### *Colour Preference—Method of Paired Comparison*

**Problem**—To determine S.'s order of preference for the colours presented.

**Apparatus and Material**—Six oblongs of coloured paper, red, yellow, green, blue, violet, magenta. Frame for colours, with cover sheet. Sloping stand. Metronome.

**Procedure**—Method of Paired Comparison.

Every colour must be presented with every other colour, and must also be presented to the right as well as to the left. Hence there are thirty possible combinations. To ensure irregular presentation, and to ensure that every possible combination is presented to the subject, designate the colours by the letters A, B, C, D, E, F. Call any colour A, another colour B, and so on, and present the colours according to the scheme below. The lettering of the colours may be different for each subject.

E. lifts frame off stand, places in the first two colours, puts cover sheet over them, and replaces on stand. The metronome is beating seconds. E. says "ready," counts two by metronome, and lifts off cover sheet. S. chooses the colour preferred, by pointing rather than by naming, and the table below is filled up. Time of choice is obtained by counting the beats of the metronome between exposure of colours and choice by S. E. and S. should change functions after every ten choices.



Left Hand.	Right Hand.	Preference.	Degree.	Time of Choice.	Reason for Choice.
B, etc.	F, etc.	F, etc.	Great. Medium. Slight.		

**Scheme of Presentation—**

BF	DA	EA	BE	CF	AB	EB	CA	FE	ED
DB	AC	DF	EC	BD	BC	CE	FD	AD	CB
FC	FB	DE	AF	BA	DC	EF	AE	CD	FA

## EXPERIMENT 44

### *The Method of Impression—Serial Method*

**Problem**—To study the nature and characteristics of the affective element in experience.

**Material and Apparatus**—Four rectangles of coloured paper—red, green, blue, yellow. Galton whistle. Tuning fork giving C or A. File and metal dish. *Tonmessenger* (or some source of sound to give pleasant clang complex). Metronome.

**Procedure**—First Series—*Colours*—The colours should be presented one at a time in the same way as in the paired comparison experiment. E.'s instructions to S. are in these terms: "You will be presented with a series of colour stimuli. Concentrate your attention on the feeling side of the experience you have, and describe your experience as fully as you can."—E. then says "ready," and on the second beat of the metronome thereafter lifts the cover sheet and exposes the colour. S. describes his experience, and E. takes down the description. It is advisable that students should read over "protocols" as in Wohlgemuth's "Pleasure and Unpleasure" before beginning this experiment.

The same procedure is followed with the remaining colours. E. and S. then change functions, and the experiment is repeated, preferably with other colours.

Second Series—*Sounds*—The same procedure is followed *mutatis mutandis* as in the case of the colours.

A third, fourth, and fifth series may be taken, with colours in pairs, sounds in pairs, and a sound and a colour together. These series afford an excellent opportunity for the study of the problems of mixed feelings and localization of feeling.

## EXPERIMENT 45

### *The Method of Expression—The Pneumograph*

**Problem**—To compare the rate and amplitude of normal breathing with the rate and amplitude under conditions of (a) concentrated attention and (b) disagreeable sensation.

**Apparatus and Material**—Pneumograph. Recording

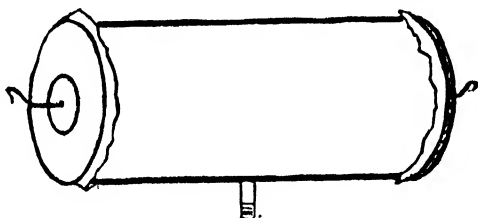


FIG. 8.—Simple pneumograph.

tambour. Clock-work kymograph. Time marker ( $\frac{1}{2}$ -seconds). Metal and file.

**Procedure**—E. should secure that the pneumograph is in the best position possible for recording S.'s breathing. The tape fastened to the end hooks, and passing round S.'s body, should be firmly but not too tightly fastened.

To obtain the normal breathing curve, S. is seated in an easy position with his back to the kymograph, and

reading quietly. E. adjusts tambour and time marker to obtain a record, and then starts the drum, which should be going at a fairly slow rate. After one complete revolution E. stops the drum. E. and S. should change functions at this point, the new E. using the lower half of the same drum.

The marking levers of the tambour and time marker are now moved down on drum, so as to get a fresh record. To begin with normal breathing is recorded as before. Then E. gives S. a multiplication of three digits by three digits to do mentally, S. keeping his eyes closed during the process. E. should place a cross on the drum indicating the point at which he gave S. the digits to multiply, and the point at which S. gave the answer. Again E. and S. change functions.

A third record is begun with normal breathing as before, after the levers have been moved down. Then without warning, E. or the instructor makes an intensely disagreeable sound by drawing the file over a metal dish or sheet, and continuing for some seconds. This is repeated two or three times during the revolution of the drum. Crosses should be placed as before indicating the points at which the sound began and ended. E. and S. change functions once more.

**Results**—The paper is removed from the drum and varnished, after the necessary information for subsequent identification and use have been recorded on it. When the records are dry, the rate and amplitude of normal breathing should be compared with the rate and amplitude in concentrated attention, and under the influence of a disagreeable experience.

## EXPERIMENT 46

### *The Psycho-galvanic Response*

**Problem**—To study the psycho-galvanic response under different conditions.

**Apparatus and Material**—Sensitive moving-coil galvanometer with mirror and scale. Two constant resistances of 50 and 500 ohms respectively. Dial resistance with four dials—units, tens, hundreds, and thousands. Zinc electrodes for palm and back of hand respectively. Pads. Basin with strong salt solution. Two-volt dry cell or accumulator. Wiring. Needle. Electric bell. Klaxon horn. List of words for free association.

**Procedure**—Connect up resistances and galvanometer in Wheatstone bridge arrangement as shown in diagram. S.'s left hand is placed between electrodes in one arm of the bridge. The best arrangement is to soak two pieces of some woven fabric such as cotton, in the concentrated salt solution, and place them folded on the back and palm of the hand respectively. Over these are then placed the zinc plates, and the whole is then fastened firmly by means of two strong rubber bands. Care must be taken to have as close contact as possible, and to avoid any short circuiting between the pads or the plates.

When S.'s hand has been thus fixed in one arm of the bridge, its resistance is carefully balanced by means of the dial resistance, so that the spot of light remains at

zero when the circuit is made. It will generally be found that frequent readjustment of the dial resistance is necessary as the experiment proceeds. A record must be kept of the resistances from time to time.

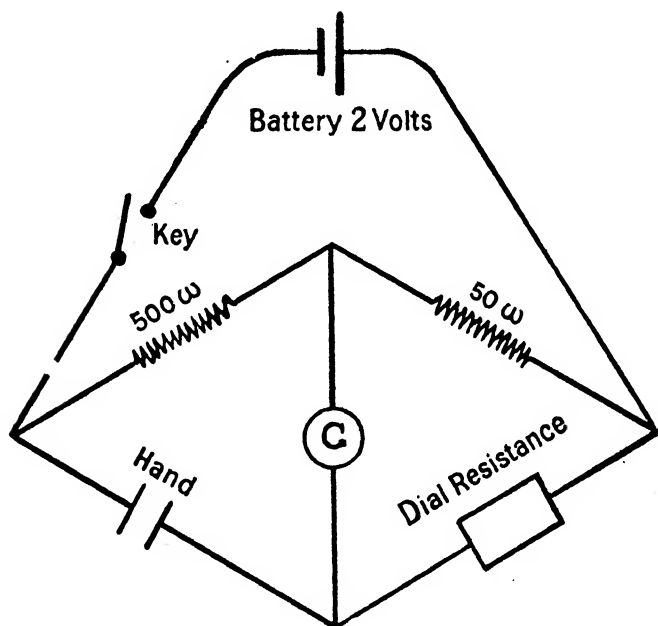


FIG. 9.—Wheatstone bridge arrangement for psychogalvanic response.

E. will now give S. a series of stimuli arranged somewhat as follows :—

- Prick with needle.
- Prick with needle.
- Electric bell.
- Electric bell.
- Electric bell.

Prick with needle.

Threatened prick.

Klaxon horn.

Klaxon horn.

Klaxon horn.

Threatened prick.

Prick with needle.

In each case E. will note the position of the spot of light on the scale, when the stimulus is given, and the position to which it swings as a result of the stimulus.

A further series of experiments should be carried out, if time allows, in which responses to a series of stimulus words with free association are recorded:—

Resistance of S.	Stimulus.	Initial Position of Spot.	Final Position of Spot.	Shunt.	Deflection.



## EXPERIMENT 47

### *Learning (Learning and Saving Method)*

**Problem**—To study the process of committing to memory nonsense material.

**Apparatus and Material**—Material to be learned consisting of twelve of Seashore's figures as illustrated. Stop-watch or stop-clock. Strips of paper for reproduction.

**Note**—Seashore's figures are formed by drawing three lines—two equal to one another and the third half the length of these—either so as to meet at right angles, or at an angle of  $45^\circ$  (or its supplement). The longer lines should join one another, and no two lines should cross.

**Procedure**—Each E. draws carefully on a page of his notebook twelve of Seashore's figures, one E. adhering to rectangular figures and the other to figures with lines at  $45^\circ$ . This constitutes the material to be learned.

In the learning E. exposes the figures for 10 seconds. S. then attempts a reproduction. E. takes S.'s reproduction and records the figures correctly reproduced, but does not tell S. which are correct and which are not correct. E. then gives another exposure as before, and S. attempts a second reproduction, and this procedure is continued till the first correct reproduction is secured. No stress is laid on the order of the figures. E. and S. then change

functions, and the experiment is repeated with the new S. and the other set of figures.

Each E. should plot a curve of learning showing number of figures correctly reproduced against number of ex-

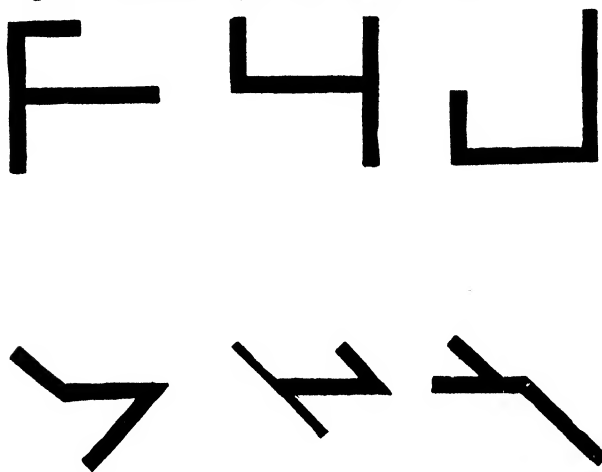


FIG. 10.

posures. E. should also note which figures are learned first, and try to correlate the order of learning with the order of presentation. Retention may be tested by the number of exposures necessary to secure the first correct reproduction after the lapse of an interval of time.

Each S. should write as detailed an account as possible of the way in which, and means by which, he memorized the figures, noting particularly the type of imagery employed, the part played by meaning, etc.

## EXPERIMENT 48

### *Learning—Card Sorting (after Pyle)*

**Problem**—To study the process of semi-motor learning, and the effect of interference.

**Apparatus and Material**—Pyle's card-sorting tray. Numbered cards. Stop-watch.

The card-sorting tray contains on the one side 30 compartments numbered from 11 to 40 in haphazard order, and on the reverse side also 30 compartments with the numbers arranged in a different order. Each card has on it one of the numbers from 11 to 40, and there are five cards for each number.

**Procedure**—E. mixes the cards thoroughly, and S. is instructed to place each card in the appropriate compartment as quickly as possible. When he is finished there should be five cards in each compartment. In the insertion of the cards in the compartments care must be taken that the numbering is not hidden. E. records the total time taken to sort the cards. E. and S. change functions. Five sortings each should be taken each day for 4 days, making twenty sortings in all, the cards being well shuffled each time. The curve of learning should then be plotted, showing time taken against trials. As sorting depends partly on speed of movement, which also to some extent improves with practice, it is advisable to test this. This can be done by instituting two speed

tests daily, one at the beginning of the day's sorting, one at the conclusion, S. being instructed to sort the cards into the compartments irrespective of numbers. It will be found that, while quickness of learning the association of number with compartment plays the more important part in determining the curve of learning at the beginning, speed of movement is more important later. The time of the speed tests gives a fair idea of the time to which the real sorting can approximate.

To study the effects of interference the tray should be reversed for each S., and S. should endeavour to sort the cards into the differently numbered compartments. Five sortings should be taken with speed of movement tests before and after. The interference effect is shown by a comparison of the results of these five trials with the results of the five trials made on the first day of the original sorting. It must be remembered that the total time is a composite time involving both muscular and mental factors, and the interference effect will only be shown in the case of the latter. Hence the speed of movement time must be subtracted from the total sorting time for comparison purposes.

## EXPERIMENT 49

### *Learning—Interference (After Pyle)*

**Problem**—To study interference in learning.

**Apparatus and Material**—Stop-watch. Pyle's marble sorting apparatus. This consists of a rectangular box divided into four columns to hold the marbles. This is so arranged on an inclined plane that as a marble is lifted from any one column the next marble takes its place. The box has a lid which allows only the bottom row of marbles to be visible. The marbles are of nine colours, and these are to be sorted according to colour into a second box having nine compartments. The lid of this box has nine holes, and above each hole can be placed the picture of an animal outlined in black and white. In front of S. is placed a card containing pictures of the same nine animals as on the lid of the box, but each coloured in a different colour, and arranged in a different order from the arrangement on the lid. S. is asked to sort the marbles according to colour by consulting the card, finding out which animal has the same colour as the marble, and then placing the marble in the compartment of the box beneath the picture of the animal in question.

**Procedure**—E. says "ready" to S. and then "go" at the same time starting the stop-watch. S. begins sorting the marbles by lifting the bottom marble from

each row successively until all the marbles have been used. The time is then recorded, and any errors made. This is repeated six times, or until the sorting has become automatic.

A second card is then placed before S. in which the animals are differently coloured, and the position of the animals on the lid of the box may also be changed by E. The sorting of the marbles is then proceeded with as before, and the times of each trial noted. Probably three sortings will be sufficient with this second arrangement.

S. and E. may change functions after each sorting, but of course, it is advisable to have a separate card for each S.

**Results**—Draw learning curves for the two parts of the experiment and compare results.

## EXPERIMENT 50

### *Mirror-drawing—Trial and Error Learning*

**Problem**—To study the establishment of a new co-ordination of hand and eye in trial and error learning.

**Apparatus and Material**—Mirror. Cardboard screen for hand with supports. Stop-watch. Figure to be traced (star, shamrock, etc.). Tracing paper. Drawing pins.

**Procedure**—E. pins down figure to be traced on table, with a sheet of tracing paper over it, and places mirror and screen so that direct vision of the figure is cut off from S., and he sees only the reflection in the mirror. S. places pencil in centre of figure. The point at which he is to start tracing the figure should be marked with a X or the number "1," and should be the point farthest away from him. He is instructed to begin at this point and to move round the figure in an apparently clockwise direction as seen in the mirror until he comes back to the starting point, when he is to bring the pencil to rest in the centre once more. E. says "go" and starts the stop-watch. S. proceeds to trace the figure as directed, and when he gets back to the centre after finishing the tracing, E. stops the watch and records the time. After S. has done a second tracing in the same way on a new sheet of tracing paper, E. and S. change functions, and the new S. does two tracings. The experiment should be

repeated until six tracings are done by each S. These should be arranged in the following way, one tracing with the left hand, then four tracings with the right hand, and then another tracing with the left hand.

A curve of learning should be drawn based on the time taken for the respective tracings, and the tracings of each S. examined and analysed, the number of errors in the form of erroneous direction of movement being recorded for each tracing. Also compare the times taken by the left and right hands.

If E. and S. take two further tracings a week later, without any practice in the meantime, the effect of lapse of time will be shown.



## EXPERIMENT 51

### *Learning—Substitution*

**Problem**—To study the learning curve.

**Materials and Apparatus**—Stop-watch; cyclostyled sheets of letters as below, with key at top. (Double spacing between rows of letters.)

#### Series I

Z	M	H	V	F	O	K	R	G	D	L	X
1	2	3	4	5	6	7	8	9	10	11	12
L	O	K	F	M	Z	V	H	L	R	D	G
X	Z	V	O	L	H	F	R	V	Z	L	D
K	R	Z	G	F	D	O	K	L	X	K	V
H	Z	X	R	M	K	G	D	O	G	F	K
X	L	G	M	F	R	L	Z	H	O	D	V
X	K	M	F	X	D	Z	H	R	Z	H	X
D	F	M	V	O	R	D	X	M	Z	H	F
K	G	L	V	G	V	K	O	L	M	F	M
D	X	Z	H	Z	X	D	R	O	V	M	L
G	K	F	H	F	K	Z	O	D	H	V	X
L	K	F	O	V	O	M	V	R	D	X	L
Z	H	F	K	G	O	L	X	G	R	F	M
D	K	L	Z	R	G	K	H	O	R	L	Z
X	M	D	G	V	F	K	D	F	G	H	K
L	K	D	M	O	G	R	X	Z	M	L	D
H	V	G	R	F	O	K	R	M	O	R	V
X	Z	L	X	H	R	V	O	F	V	H	O
R	K	L	D	G	X	M	Z	G	L	K	H
G	F	D	M	F	V	G	H	Z	H	Z	F
K	G	L	M	V	O	R	D	X	D	Z	X
V	R	O	M	H	Z	G	V	M	F	D	R
O	V	M	Z	H	F	K	L	X	G	L	X
Z	M	L	D	H	V	O	R	H	L	X	M
D	F	G	K	L	M	O	R	V	X	Z	H
V	G	R	F	O	K	G	R	O	M	K	D
V	F	O	X	H	M	L	D	Z	G	R	K
F	D	V	F	L	K	R	L	O	X	V	H
D	G	K	F	H	Z	L	V	X	D	O	R
M	R	G	Z	H	L	M	X	M	O	G	R
Z	K	K	Z	X	V	R	O	M	L	H	G
F	D	O	X	O	V	H	M	K	G	L	Z
F	R	D									

## Series 2

M	L	H	Z	D	G	X	V	R	O	K	F
1	2	3	4	5	6	7	8	9	10	11	12

LOKFMZVHLRDGXZVOLHFRVZLDK  
 RZGFDOKLXKVHZXRMKGDGFKXL  
 GMFRLZHODVXKMFXDZHRZHDFM  
 VORDXMZHFKGLVGVKOLMFMDXZH  
 ZXDROVMLGKFHFKZODHVXLKFOV  
 OMVRDXLZHFKGOLXGRFMDKLZRG  
 KHORLZXMDGVFKDFGHKLKDMOGR  
 XZMLDHVGRFOKRMORVXZLXHRVO  
 FVHORKLDGXMZGLKHGFDMFVGHZ  
 HZFKGLMVORDXDZXVROMHZGVMF  
 DROVMZHFKLXGLXZMLDHVORHLX  
 MDFGKLMORVXZHVGRFOKGROMKD  
 VFOXHMLDZGRKFDVFLKRLOXVHD  
 GKFBZLVXDORMRGZHLMXMOGRZK  
 KZXVROMLHGFDXOVHMKGLZFRD

**Procedure**—The experiment may either be conducted as an individual, or as a group experiment. S. at signal “now” from E. begins to write beneath each letter in the first row of letters the corresponding figure. For example, in Series 1, he writes under L the figure 11, under O the figure 6, and so on. After S. has worked in this way for 30 seconds E. says “stop.” S. places a vertical mark after the last figure written. S. then rests for 30 seconds. The complete experiment consists of 12 periods of work each of 30 seconds’ duration, and separated by a rest pause of 30 seconds.

If used as an individual experiment, Series 2 is used for the other S.

**Results**—Count up the number of substitutions made in each half minute and plot the learning curve. In the case of errors, deduct the number of errors from the number of correct responses in any 30-second period.

## EXPERIMENT 52

### *Memory—Perseveration*

**Problem**—To study the phenomena of perseveration.

**Material and Apparatus**—Stop-watch.

**Procedure**—The experiment may be conducted either as an individual or as a group experiment.

S. is instructed in the details of the experiment beforehand, and then is timed by E.

*Test 1.*—The "S" test.

S. is asked to write the letter S continuously for 1 minute, SSSS, etc., and then to write the same letter reversed for 1 minute, 2222, etc., after which the two forms S and 2 are written alternately for 2 minutes, S2S2S etc. No interval of time elapses between any of the parts of the experiment, the complete experiment as described above taking 4 minutes.

To obtain a reliable result, the test should be repeated a number of times, say 10 times, and only the results from the last five trials counted in the final score. This helps to eliminate the practice effect which is considerable. At the same time, E. can note the constancy or otherwise of the perseveration score.

**Results**—To obtain the Perseveration score, calculate each trial separately. This is done as follows. Subtract the total number of letters made in the two last minutes, minus the number of errors, from the total number of

letters made in the first 2 minutes, and divide by two. That is, count in the second part of the experiment where the letters are alternated, the total number of letters written whether S or Z, deducting for errors. (An error is where S is written instead of Z and vice versa.) This total is then subtracted from the sum of the number of S's written in the first minute combined with the number of Z's written in the second minute, and the result divided by two.

Results from one type of perseveration test may be compared with results from others. If used as a class experiment, any individual result can be compared with the result of the group as a whole.

The smaller the perseveration score, the smaller is the tendency to perseverate, the higher the perseveration score, the greater is the tendency to perseverate.

Other tests :—

*Test 2.*—The Triangle test.

(a) Draw an equilateral triangle continuously for 1 minute  $\triangle\triangle\triangle\triangle$ .

(b) Draw an equilateral triangle reversed continuously for 1 minute  $\nabla\nabla\nabla\nabla$ .

(c) Draw these alternately for 2 minutes,  $\triangle\nabla\triangle\nabla$ , etc.

*Test 3.*—The Letter and Number test.

(a) Write the first seven letters of the alphabet in capital letters for 1 minute, ABCDEFGABCD, etc.

(b) Write the first seven digits continuously for 1 minute, 12345671234, etc.

(c) Write letters and digits alternately for 2 minutes, A1B2C3D4E5, etc.

*Test 4.*—The Division test.

(a) Write the division sign continuously for 1 minute,  $\div\div\div\div$ .

(b) Write the division sign vertically and continuously for 1 minute  $\cdot| \cdot| \cdot| \cdot|$ .

(c) Write these alternately for two minutes,  $\div \cdot| \div \cdot|$ . The perseveration score is always calculated in exactly the same way

$$P = \frac{(a + b) - c}{2}.$$

## EXPERIMENT 53

### *Methods of Learning by Heart*

**Problem**—To compare with respect to rapidity of learning and permanence of retention the method of learning a piece of poetry by sections with the method of learning it as a whole.

**Apparatus and Material**—Two pieces of poetry—A and B—of about twenty to thirty lines each. Watch or clock.

**Procedure**—One S. will take piece A, the other piece B, and proceed to learn simultaneously. Each will learn the piece as a whole. That is, he will read it through from start to finish over and over again, until he feels that he can repeat it. In the process of learning the piece should be placed on the desk in front of him; he should note the time on the clock or watch, and then begin to learn. After reading the piece through once he should attempt to reproduce, turning his eyes away from the page in front of him, but as soon as he stops or hesitates, he should immediately turn his eyes back to the page and proceed to read through once more. Each repetition should be recorded by a tick on his note-book. As soon as he has succeeded in reproducing once without looking at the page, he should turn the page face down, note the time, pause for three minutes, and then proceed to write out the piece in his note-book.

When the first learning is finished the subjects should

rest for 10 minutes. They should then interchange pieces, and each should proceed to learn the new piece by the sectional method. As before each S. notes the time at the start, and at the moment when he has secured the first correct reproduction, and after pausing for three minutes, proceeds to write out the piece in his note-book. In other respects, however, the procedure will be somewhat different. The sections should be of about four lines. Each S. should read through one section, then attempt to reproduce it. If he stops or hesitates, he should immediately turn to the text, and read once more. When he succeeds he should go on to the next section and treat that in the same way. A record should be kept of the number of repetitions required for each section. When each S. has learned all the sections separately he should attempt to repeat the whole piece, turning to the text as soon as he meets with a check. The number of repetitions of the whole till the first reproduction is secured should also be recorded.

The total number of words correctly reproduced should be counted for each piece, and the results tabulated as below. To test permanence of retention a reproduction of each piece should be attempted a week later, and the number of words correctly reproduced counted. To equate the conditions for the two pieces, the class as a whole should be used as the basis upon which final results are calculated, and as many groups should be arranged to start with the sectional method as with the entire method.

Piece.	Number of Words.	Method.	Repetitions.	Time.	Words Reprod.	Per Cent.
A.						
B.						



## A.

How pleasant, as the sun declines, to view  
The spacious landscape change in form and hue !  
Here, vanish, as in mist, before a flood  
Of bright obscurity, hill, lawn, and wood ; |  
There, objects, by the searching beams betrayed,  
Come forth, and here retire in purple shade ;  
Even the white stems of birch, the cottage white,  
Soften their glare before the mellow light ; |  
The skiffs, at anchor where with umbrage wide  
Yon chestnuts half the latticed boat-house hide,  
Shed from their sides, that face the sun's slant beam,  
Strong flakes of radiance on the tremulous stream : |  
Raised by yon travelling flock, a dusty cloud  
Mounts from the road, and spreads its moving shroud :  
The shepherd, all involved in wreaths of fire,  
Now shows a shadowy speck, and now is lost entire. |  
Into a gradual calm the breezes sink,  
A blue rim borders all the lake's still brink ;  
These doth the twinkling aspen's foliage sleep,  
And insects clothe, like dust, the glassy deep.

## B.

When, in the south, the wan moon, brooding still,  
Breathed a pale steam around the glaring hill,  
And shades of deep-embattled clouds were seen,  
Spotting the northern cliffs with lights between ; |  
When crowding cattle, checked by rails that make  
A fence far stretched into the shallow lake,  
Lashed the cool water with their restless tails,  
Or from high points of rock looked out for fanning gales ; |  
When school-boys stretched their length upon the green ;  
And round the broad-spread oak, a glimmering scene,  
In the rough fern-clad park, the herded deer  
Shook the still-twinkling tail and glancing ear ; |  
When horses in the sunburnt intake stood,  
And vainly eyed below the tempting flood,  
Or tracked the passenger, in mute distress,  
With forward neck the closing gate to press— |  
Then, while I wandered where the huddling rill  
Brightens with water-breaks the hollow ghyll  
As by enchantment, an obscure retreat  
Opened at once, and stayed my devious feet.

## EXPERIMENT 54

### *Fertility of Imagination—Ink Blots*

**Problem**—To estimate the facility or fertility of an individual's imagination.

**Apparatus and Material**—Whipple's series of ink blots numbered from 1 to 20. Stop-watch.

**Procedure**—E. arranges the twenty cards in regular numerical order in a pile face down. S. is instructed to turn over each card on the command "now" by E., and as soon as he has seen any resemblance to an object in the blot to tap on the table. E. starts the stop-watch simultaneously with "now," and stops it when S. taps. He records the object seen by S. and the time. The first ten cards are treated in this way and then E. and S. change functions. The new S. proceeds in the same way through the second ten. If there is time each S. should work through the ten done by the other S. and so complete the whole series.

**Results**—1. The mean time for a single association should be calculated.

2. A classification of objects suggested should be attempted, e.g. into everyday objects, scientific objects, literary objects, etc.

**Alternative Procedure**—The procedure is as above, but S. instead of describing one object only, is asked to describe as many different objects as possible while looking at each blot for one minute.

## EXPERIMENT 55

### *Constructive Ability—Masselon Method*

**Problem**—To investigate the constructive ability of the subject in linguistic material.

**Apparatus and Material**—Five cards each containing three nouns. Five cards each containing three verbs. Stop-watch.

**Procedure**—E. hands a card to S., on which are printed three nouns, and instructs him to make as many sentences as possible containing all three. Additional nouns may of course be used. Five minutes are allowed. E. repeats in the same way with the other four "noun" cards. E. and S. then change functions.

In the second part of the experiment the procedure is the same but the cards with verbs are used.

In the case of the nouns, singular, plural, or possessive forms may be used, and in the case of the verbs any part.

**Results**—A quantitative result is obtained by counting the number of sentences constructed. A qualitative estimate may be obtained by averaging the number of words per sentence.

List of nouns and verbs to be used :—

*Nouns* : citizen, horse, decree ; bell, ground, owner ;  
skill, modification, picture ; cup, fraction,  
money ; letter, law, summer ;

*Verbs* : bless, destroy, write ; make, correspond, remain ;  
require, choose, run ; see, find, throw ; re-  
member, put, depart ;

## EXPERIMENT 56

### *The General Factor*

**Problem**—To determine whether a general factor is influencing the results of different mental tests, and to what extent.

**Apparatus and Material**—Material for the tests chosen. Stop-watch.

**Procedure**—This experiment must be performed as a group experiment. The class may act as the group and one of the students as E. All should do the necessary calculations.

E. chooses first four mental tests. Those to be described here are the Ebbinghaus Completion Test, the Cancellation Test, the Number Series Test, and the Alphabetical Series Test.

(1) *The Ebbinghaus Completion Test*—Special material should be prepared by E. beforehand on the model of the following from Whipple (the words here italicized being omitted) :—

#### *" The Strength of the Eagle*

" One *day* the eagle *went* with the *other* birds to see *which* could fly *the highest*. They agreed *that* he who *could* fly *the highest* should be called *the* strongest *bird*. All started *at the same time* and *flew* away among *the* clouds. One by one they *grew* weary and *returned*, but

*the eagle flew upward and upward until he was a mere speck in the heavens. When he came back the others, etc."*

The prepared passage should be shown to the instructor for approval. There ought to be from 60 to 80 elisions, and the whole should be of such a length and difficulty that the fastest worker should be just not able to finish it in five minutes.

A printed or cyclostyled copy of the material should be placed face down on the table in front of each subject. E. instructs the subjects on the word "begin" to turn over the sheets and proceed to fill in the blank spaces with the appropriate words as quickly as possible. He allows five minutes for the test and then says "stop."

The score is taken as the number of the blank spaces correctly filled in.

(2) *The Cancellation Test*—A cyclostyled or printed copy of the following series of lines of "printer's pie" should be placed face down on the table in front of each subject. E. instructs the subjects to turn over the sheets on the word "begin" and to cancel out the vowels "a" and "i" as quickly as possible. He allows as before five minutes for test, and then says "stop."

In this case the score must represent both the quantity and the quality of the work. The quantity may be measured by the total number of letters covered by the subject—T—the quality by the accuracy of the cancelling, a formula for which would be:—

$$\frac{c - w}{c + o}$$

where "c" is the number of letters correctly cancelled, "w" the number wrongly cancelled, and "o" the number omitted.

The product

$$T \times \frac{c - w}{c + o}$$

will then give the score.

### PRINTER'S PIE.

dkagbafwkqpvarsoicalmyfluavqualakaaralvqufgkbqkarsmi  
fcwavqpagabqgxazahdracmyfulvwpsaelafgahaataagattmyr  
ttfahpigfawhectmayvqftwwaagbahadnascoramqkgxabwam  
ayaractbsgbfaacesiohntargyluvggkmuchgdbfawxqqutarohr  
nmcd eisfwgkbbfacegbjjzyuvnohgeisfwratuvxqylmnhoppsfr  
wiedcgkbzzjjsinclairairsirwilliamhopesigndcmlyjzbkqxutan  
rpposienhockgdeethatncmzkwxqvutarpohnmlyjzcbdeisfwlf  
pgkznofsoarhnqbdtnmuarwposhendgohoptnmharleydanow  
psegkzjbqxvuwrisentoseedmcukglxvutarpoidhratuvxqyln  
mnhopwfsiedcbjzkg eisfwroapisehtndgkccmuvlbzjyqxstomc  
lovebertthathedoseetnmckklybjisfwrapsiohegdntumcbklvls  
xqitrjoyzalexandersioehndgkcmutylbjzxqyvutarpohnmdea  
isfwdndojoykaturphonmlvxyqfcbdsgeisfwoehndartnicoledo  
mundsandclarkdarosohngeiwdcutvluyzvxxekgdeisraaopprac  
tnd eiswfcmnhutoegjoheiowhughhasarousedtheplaceonhikgl  
cmutlyejzxtuhovpqrwfsiedcblnmarophentamuvlybcdeisfw  
ggkznoptaruzmlyjceackwfsisoparhendtucdkbmuthaopisedgs  
kcbjxvhielyheallynopwpeacednitoafzjmneahtckaropwfsief  
htndgkcmuvlbjyxzsfioarwhegndtumckbxyvlbjkcdesfoairh  
atlmnhopswfeidgkcmnotlybqtxzjohendgisanthisepticsthcl  
ompocssehodyzbodynotsifwratnhcckglybqaprosfeiwndhtn  
umckgqxvbqptulyvmnxyzcdkbeighonsarwfoegnohtmkckcm  
nuvvqxyljcisoahtrnmdkcmngblyheiospwartuvycdephtonr  
thestairsenoughlyqxjceeghopealexandernoptmckkvylurraw  
wisfegdhntarsoukdmhatsenikcsudropoareiprocrastinationw  
plyckbjuntheisybqxvjzkgcnhopsifntarwiehndsoehfromntdo

csinkingielsandsqqvlyheliftedgkcntumearopsehndreifwbre  
 deemerwhenclyzjqxvmunthdckeisoharwfghearophtunmeioi  
 kgkcdntumoarpwfegmcblyzyxvutoistwageornostmkntaohn  
 gguvlysolobeautifullyseekbcntdehopswfgiuvxylymoartpieif  
 hndsifnckbbxdxyzjuabcdeisfgnohistparwnmtuxvqzaropsiw  
 gkcdentuvlybqdepzigsraoiedsuvlyxmnhtaroepiswlgkarohnf  
 mcdgkbjiarphoisfenhtamcklyszxqmarrohntaedckgiseohntw  
 arwfsoplybqmngthedioarpoisfgekbyxvutmnhoarpwsiedcs  
 bjzkgdeisfwhontareiokmnttubjyxlvwsoaieisrathndgcmubjy  
 xvhopparwnhgtuvlyxbcgenghisopkcluthoarwfpoeiquackasi  
 rsopiehnqdcqlyxvbjzkcmmhisopartedsifowhncblyvqxonif  
 lymnopsragfwtmchdegkoraptnulvyjzxonurohipwiendguf  
 thoarwaopraihndegkcmulvxqybzcnoheiswfargnthmcklyiw  
 sohntuarosfwpiroapesidnthemuvqyxjzbcddmnyaredgiswfnts  
 hnmulyxvhharoisphoeinmcdeisfwgkbbfacegbjjzyuvnohgeis

(3) *The Number Series Test*—A printed or cyclostyled copy of the following number series should be placed face down on the table in front of each subject. E. instructs the subjects to turn over the sheets on the word "begin," and to fill in the blank spaces with the appropriate numbers as quickly as possible. He allows as before 5 minutes for the test and then says "stop."

The score is taken as the number of spaces correctly filled in:—

# NUMBER SERIES

1	2	4	8	—	32	—	128
8	1	6	1	4	1	—	—
1	—	5	7	9	—	13	15
10	—	—	25	30	35	40	45
22	19	16	—	10	—	4	1
16	12	—	11	14	—	13	9



NUMBER SERIES (*cont.*)

2	7	4	—	—	11	8	13
3	6	8	16	—	36	—	76
—	—	43	35	27	19	11	3
5	8	10	—	15	18	—	23
11	14	—	16	15	—	17	20
1	4	—	—	22	25	50	53
20	16	18	14	—	—	14	10
23	26	—	—	31	34	35	38
—	8	10	—	22	44	46	92
143	114	88	—	—	28	14	3
29	28	—	25	—	23	21	20
63	—	31	—	15	14	7	6
20	17	—	14	11	9	—	5
—	14	17	—	16	12	15	11
1	—	9	16	—	36	49	64
21	18	16	15	—	—	9	6
81	27	54	—	36	12	24	—
2	—	—	8	12	17	23	30
2	—	6	15	42	—	366	1095

(4) *Alphabetical Series Test*—A printed or cyclostyled copy of the following alphabetical series should be placed face down on the table in front of each subject. E. instructs the subjects, as in the previous tests, to turn over the sheets on the word “begin,” and to fill in the blank spaces with the appropriate letters as quickly as possible. He allows as before 5 minutes for the test and then says “stop.”

The score is taken as the number of spaces correctly filled in.

## ALPHABETICAL SERIES

(Here is the alphabet : a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, v, w, x, y, z.)

z	x	—	t	r	—	n	l	
a	c	d	—	—	i	j	l	
a	c	e	—	i	k	—	o	
z	w	—	q	n	—	h	e	
b	c	e	f	—	i	—	l	
a	d	c	f	—	h	g	—	i
x	v	s	q	—	—	i	g	
z	v	w	s	—	p	q	—	
c	a	e	c	—	e	i	—	
q	m	n	—	k	g	—	d	
a	c	b	f	d	f	—	i	—
z	v	x	v	w	s	—	s	—
a	b	d	g	h	j	—	o	—
x	y	—	s	r	p	l	—	j
a	b	e	g	j	k	—	—	s
z	x	w	—	s	q	p	m	—
f	i	h	j	—	l	k	—	l
z	y	v	—	p	m	h	g	—
a	—	g	h	l	n	—	s	u
a	j	g	—	j	p	—	s	p
z	w	u	t	—	q	p	o	—
e	g	i	—	o	q	u	—	y
w	—	s	o	m	k	—	e	c
l	n	j	l	—	j	f	—	
m	n	l	—	k	p	j	q	—

**Treatment of Results**—Tabulate the scores as follows :

Subject.	Test 1.	Test 2.	Test 3.	Test 4.

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Calculate (a) the mean score for each test ; (b) the standard deviation ( $\sigma$ ) for each test ; (c) the correlation between (1) and (2), (1) and (3), (1) and (4), (2) and (3), (2) and (4), (3) and (4), using the "product-moments" formula (p. 14).

Make out a table of the correlation coefficients as follows :—

	(1)	(2)	(3)	(4)
(1)	—	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>
(2)	C <sub>1</sub>	—	C <sub>4</sub>	C <sub>5</sub>
(3)	C <sub>2</sub>	C <sub>4</sub>	—	C <sub>6</sub>
(4)	C <sub>3</sub>	C <sub>5</sub>	C <sub>6</sub>	—

Fill in the coefficients C<sub>1</sub>, C<sub>2</sub>, C<sub>3</sub>, C<sub>4</sub>, C<sub>5</sub>, C<sub>6</sub>, as above. Take four coefficients at the angles of a rectangle, e.g. C<sub>2</sub>, C<sub>3</sub>, C<sub>4</sub>, and C<sub>5</sub>. This is known as a "tetrad." Cross multiply C<sub>2</sub> by C<sub>5</sub>, and C<sub>3</sub> by C<sub>4</sub>. The difference between the two products should not be significantly different from zero if there is a "general" factor.

$$(C_2 \times C_5) - (C_3 \times C_4) = 0.$$

## EXPERIMENT 57

### *Performance Tests*

**Problem**—To test an individual's intelligence by means of a scale of performance tests.

**Material and Apparatus**—Drever and Collins' Scale of Performance Tests.<sup>1</sup>

**Results**—Find total score and compare with norms below.

#### POSSIBLE SCORE 148

	Boys. Medium.	Lowest Quartile.	Highest Quartile.	Girls. Medium.	Lowest Quartile.	Highest Quartile.
5-6	18	10	35	18	14	27
6-7	35	26	52	29	22	34
7-8	43	31	55	37	27	50
8-9	56	44	71	45	29	60
9-10	71	58	85	60	40	73
10-11	79	62	96	72	60	90
11-12	92	73	105	79	65	93
12-13	94	79	108	85	71	102
13-14	105	87	120	92	75	106
14-15	111	94	123	100	79	111
15-16	114	100	129	104	85	116

In the above table are shown the medians, together with the lowest and highest quartiles for both boys and girls; that is to say, the middle score, the score above which 75 per cent. of the cases are found, and the score above which 25 per cent. of the cases are found

<sup>1</sup> For material apply to A. H. Baird, Lothian Street, Edinburgh. For instructions for administering scale, consult Drever and Collins, "Performance Tests of Intelligence," published by Oliver & Boyd.

## EXPERIMENT 58

### *Performance Tests*

**Problem**—To test an individual's intelligence by means of performance tests. These are of necessity individual tests.

#### *A. Cube Construction Test*

**Material**—Three wooden blocks as in Fig. 10. One inch

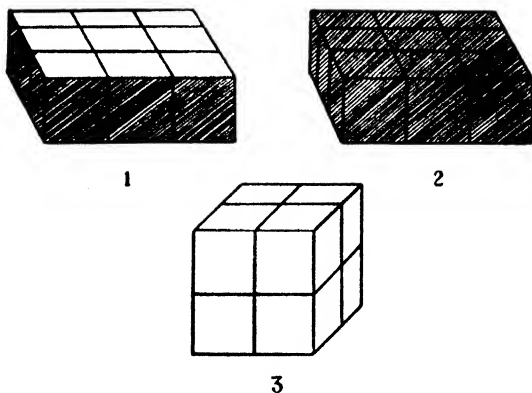


FIG. 11.—Cube construction test. Shading indicates portions which are painted grey.

cubes in three separate sets of 9, 9, and 8 respectively.

**Procedure**—E. places before S. model number 1 and the

nine cubes necessary to construct a similar model. E. points out to S. that the model is painted round the sides but not on top nor on bottom. He then proceeds to put the nine cubes together, drawing attention to the painted or unpainted condition of each block as it is fitted into its place. E. then places before S. the same model and blocks, the latter in irregular order and asks S. to place the blocks together to resemble the model.

E. then places model number 2 before S. with the nine blocks needed for its construction, and warns S. that the model is painted round the edges and on the top but not on the bottom.

Model 3 is now placed before S. and the appropriate eight blocks. E. warns S. that the model is entirely unpainted and that of the small cubes, three of the sides are painted, three unpainted.

**Treatment of Results**—Record the number of moves made by S. (changing the face of a block does not count as a move), also the time. The time limit is two minutes. If S. finishes before the time, he may make spontaneously any alterations, the extra time and additional moves being noted. In compiling results finally, each block if out of place is reckoned as three additional moves and each unassembled block as six additional moves. No credit is given for time if all the blocks are not assembled.

Models 1 and 2. Moves.	Model 3. Moves.	Points.
9	8	5
10-11	9-10	4
12-15	11-15	3
16-25	16-25	2
26-50	26-50	1

Model 1. Seconds.	Models 2 and 3. Seconds.	Points.
1-10	1-20	5
11-25	21-30	4
26-50	31-50	3
51-80	51-80	2
81-120	81-120	1

The total score is obtained by combining the marks for moves and for time. The results should be compared with the norms below.<sup>1</sup>

Mental age	5	6	7	8	9	10	11	12	13	14	15	16	
Score	.	—	2	3	5	7	9	10	—	11	17	18	20

### B. *The Knox Cube Test*

**Apparatus**—Five 1-inch cubes.

**Procedure**—E. places four cubes in front of S. about 2 inches apart. E. holds the fifth cube in his hand and says to S. "Watch carefully and then do as I do." E. then taps cubes in a certain definite order about one tap per second, beginning always with cube at S.'s left. After each trial, E. places the cube equidistant between the third and fourth cubes and says to S. "Do that." E. continues until S. fails in three successive lines.

**Treatment of Results**—E. simply scores the number of lines in which S. passes, and then compares results with norms below.<sup>2</sup>

The taps to be given are defined below, where 1 represents cube at S.'s left.

<sup>1</sup> These norms are taken from Report Number 31 of the Industrial Fatigue Research Board by Miss Frances Gaw.

<sup>2</sup> These norms are taken from Report Number 31 of the Industrial Fatigue Research Board by Miss Frances Gaw.

- |               |               |                 |
|---------------|---------------|-----------------|
| (a) 1-2-3-4   | (e) 1-4-3-2   | (i) 1-3-1-2-4   |
| (b) 1-2-3-4-3 | (f) 1-4-2-3   | (j) 1-4-3-1-2-4 |
| (c) 1-2-3-4-2 | (g) 1-3-2-4-3 | (k) 1-3-2-4-1-3 |
| (d) 1-3-2-4   | (h) 1-4-3-2-4 | (l) 1-4-2-3-4-1 |

Mental age	5	6	7	8	9	10	11	12	13	14
Score	.	2	4	5	6	—	7	—	—	8

### C. Form Board

#### (Healy Puzzle A)

**Apparatus**—Wooden frame and five rectangular pieces.

**Procedure**—E. arranges the five rectangular pieces before S., the three large pieces being separated from each other by the two small equal-sized pieces. E. says to S., "Put this together as quickly as you can."

**Treatment of Results**—E. records time taken by S. and the number of moves. The time limit is five minutes. Then compare results with the norms below.<sup>1</sup>

Mental age	8	9	10	11	12	13
Time	. 300-258	257-145	144-96	95-78	77-66	65-
Moves	. 100-51	50-39	38-32	31-27	26-21	20-

### D. Healy Picture Completion Test

**Apparatus**—Healy's picture which represents ten simple activities in an out-door scene from which ten squares have been cut, taking out an object significant in each activity. 50 square blocks, each the size of the cut-out spaces, of which ten bear appropriate objects, and ten are blank, the other 30 bearing objects which are not appropriate.

<sup>1</sup> The norms are from Pintner and Paterson, "A Scale of Performance Tests."



<i>B. Window</i>	<i>Cat</i>	<i>Hat</i>
B. Window . 100	Cat . . 81	Hat . . 65
C. Window . 32	Baby . . 4	Baby . . 3
Blank . . 2	Chicken . . 2	Books . . 1
Cage . . 1	Cup . . 1	Cat . . 2
	D. Cat . . 7	Chicken . . 1
<i>Dog</i>	Fruit . . 1	Dog . . 1
Dog . . 64	M. bottle . . 4	F. Bird . . 1
Baby . . 2	F. Bird . . 2	Mouse . . 2
Blank . . 2	S. Cat . . 2	Purse . . 3
B. Window . 1	S. Bird . . 1	
Cat . . 2	Stool . . 1	<i>Chicken</i>
D. Cat . . 2		Chicken . . 58
Hatchet . . 1	<i>Football</i>	Baby . . 1
Mouse . . 1	Football . . 84	Cat . . 2
S. Bird . . 1	Baseball . . 21	Cherries . . 2
Stool . . 1	Cherries . . 2	Cage . . 1
	F. Bird . . 1	D. Cat . . 1
<i>Log</i>	Pumpkin . 1 or 84	F. Bird . . 1
Log . . 52		Hatchet . . 1
Blank . . 1	<i>F. Bird</i>	Mouse . . 1
Hatchet . . 6	F. Bird . . 87	S. Bird . . 2
Stool . . 2	Basket . . 2	
	Cage . . 7	
<i>Basket</i>	Cherries . . 3	
Basket . . 55	S. Bird . . 18	
Bucket . . 2		
Cherries . . 7		

Norms.						
Mental age	5	6	7	8	9	10
Score .	5-42	43-98	99-177	178-270	271-326	327-365
Mental age	11	12	13	14	15	
Score .	366-395	396-415	416-445	446-460	461-	

**Procedure**--The picture and the 50 blocks are placed before S., the latter in haphazard order. He is instructed to fill in the empty spaces by putting in the appropriate objects. E. points to the wagon and asks S. what the man is looking for. If S. answers "wheel," E. tells him to select out the wheel from the 50 blocks and place it in the hole. If S. is doubtful, E. explains more fully. Then E. directs S. to fill in the other spaces in the same way by selecting the object most appropriate in each case. The time limit is ten minutes.

**Treatment of Results**—Score results for each picture from table above, and compare total score with the given norms.<sup>1</sup> It is permissible to score the pumpkin full marks (84) if on questioning the S. later, it is found that he mistook it for a football.

<sup>1</sup> The norms are from Pintner and Paterson, "A Scale of Performance Tests."

## EXPERIMENT 59

### *Graded Mental Tests*

Individual testing using any graded mental scale requires considerable practice and experience. A single experiment is therefore entirely inadequate to secure the requisite training.

Before using any graded scale the student must familiarize himself with the tests and the instructions. From the prescribed procedure there must be no deviation whatsoever. As a first step in the application of graded scales the "Herring Revision of the Binet Tests" may be tried out by each group of two. These tests are published in book form with complete instructions and material. The scale is divided into five sections A, B, C, D, E. A mental rating can be obtained from the tests of any section, and a table is appended to each section giving the mental ages corresponding to the scores obtained. Each E. should give his S. the full series of section E, but should calculate out the mental age at the end of each section. (Section B includes section A, section C includes B and A, and so on.)

After obtaining an insight into individual testing in this way each student should apply either the Stanford Revision of the Binet Scale by Terman, or the London Revision by Burt to a number of children according to time and opportunity until the necessary experience is gained.

## EXPERIMENT 60

### *Group Tests*

A group intelligence test should be given to the class as a whole. Several suitable group tests are available, such as : American Army Tests, Otis Tests, Thomson's Northumberland Tests, Ballard's Chelsea Tests, Thurstone's Psychological Examination, etc.

The tests should be given in accordance with the directions, and marked at the time by the students. The results should be put on the blackboard, the necessary calculations made, and comparison instituted with the norms.

## SUPPLEMENTARY EXPERIMENTS

### EXPERIMENT 61

#### *Constancy Phenomena—Brightness*

**Problem**—To determine the extent to which S's perception of the degree of brightness or darkness of a shadowed white field deviates from the objective "physical" brightness.

**Apparatus and Material**—Two colour mixers, A and B in figure, one with white disc, the other with white and black discs, arranged so that the sectors can be varied. Grey background behind A and B and screen separating them. A grey screen with two small rectangular apertures, arranged so that part of one disc is seen through one aperture and part of the other disc through the other (called "Reduction Screen"). Light, preferably daylight lamp if experiment is carried out in daylight. Chin rest.

**Method**—Place screens, colour mixers, and light as shown in Fig. 12, B being in the shadow cast by the screen. The shadow should not be too deep; otherwise complications arise later. Both colour mixers should be equidistant from S, at a distance of 12 to 15 feet, and placed so that S can see both easily without moving head, which is kept in same position by chin rest.

*First Part*—E requires to determine what proportion of black must be added to the white on colour mixer A, so that when it is rotated the two colour mixers A and B appear equally bright to S. The Method of Limits by Complete Ascent and Descent should be used, and at least five double series should be taken.

It is advisable that E should determine roughly where equality lies by a preliminary series before beginning the experiment proper. In the experiment proper he should begin with the variable disc too bright, and proceed by steps of 2 degrees, passing through equality, till the variable appears too dark. Then, beginning with it still darker, he should reduce the black by similar steps, till the variable appears too bright. To get equality E takes the average of five such double series. E and S then interchange, and the experiment is repeated with the new S.

*Second Part*—A reduction screen, as described, is placed between S and the discs, about 3 feet from S, but always at such a distance that the one aperture is filled with a portion of the surface of A, and the other with a portion of the surface of B. E now repeats the experiment, proceeding precisely as before, and again taking, at the end of five double series, the average size of the black sector required for equality. (This now gives the physical measurement of the degree of shadow on B).

**Result**—The simplest measurement of the degree of constancy may be obtained by taking the difference between the white-black ratio without the reduction screen and with the reduction screen. A simple coefficient of constancy can be obtained by the formula:  $1 - x'/x$ , where  $x$  and  $x'$  are the amounts of white without and with the reduction screen.

## EXPERIMENT 62

### *Constancy Phenomena—Size*

**Problem**—To determine how far the apparent size of a seen object is dependent on its actual size, rather than on the size of the retinal image—"phenomenal regression" towards the real object.

**Apparatus and Material**—First Method (with Aubert diaphragm): Two squares of thick white cardboard, 15 to 18 cm. Black background. Chin rest. Arrangement, such as large Aubert diaphragm, by means of which the size of one of the squares can be varied continuously, without changing the shape of the square. Millimetre scale.

**Procedure**—The squares are placed with the diagonal vertical, one (the standard) at a distance of 2 metres from S, the other (the variable) at a distance of 1 metre, the surfaces in both cases being normal to S's line of vision, and the two appearing in the field of vision side by side or one above the other.

In a preliminary series of experiments E determines roughly at what size the nearer square *looks* the same size as the more distant.

In the experiment proper E begins by setting the variable square at a size appreciably below the point of subjective equality, and increases by intervals of 2 mm.,

using the Method of Limits by Complete Ascent and Descent, until S gives "greater" in two successive presentations. E then presents variable at a size above the point of subjective equality, and diminishes by 2 mm. until S gives "smaller" in two successive presentations. The double series is repeated five times.

S should fixate a point on the table in front of him, while E is changing the variable, and look only when E says "ready" or "now."

**Result**—Calculate the average size of variable which S finds equal to the standard.

A simple expression for the "coefficient of phenomenal regression" is given by the ratio of the side of the subjectively equal square to the size it ought to be if dependent on the size of the retinal image, which can be derived from the geometry of similar triangles.

Thus :

$$\frac{\text{estimated size}}{\text{actual size of standard} \times \text{relative dist.}} = \text{coeff.}$$

**Material**—Second Method (where Aubert diaphragm is not available. One standard square of side 12 to 14 cm. A series of thin cardboard squares ranging from 4 to 16 cm. with a difference of 2 mm. (This is a much larger range than the experiment is likely to require, but ought to be available.) Two light wooden stands for the cards. Black background as before.

**Procedure**—The same procedure as before should be followed, the different series being made up from the range of sizes available, as indicated by the preliminary experiment. Different relative distances may be employed, and other modifications of the experiment tried.

**Result**—Calculated as before.



## EXPERIMENT 63

### *The Size-Weight Illusion*

**Problem**—To determine the amount of the size-weight illusion when the variable is three times the size of the standard.

**Material**—Ten canisters of identical appearance, but differing in weight—each by a regular increment of 2 to 4 gr. above that below it, the lightest being 64 gr. Standard canister the same diameter of base, but one-third the height, and 70 gr. in weight. Metronome. Screen, string fixed 1 ft. above table, horizontally between two retort stands. Canisters should be numbered on base, 1, 2, 3, etc.

**Procedure** (Method of Limits)—Employing Complete Ascent and Descent procedure; and starting with a canister, which is judged as definitely lighter than the standard, E goes on until S has given the judgment “heavier” twice in succession. The descending series starts with a canister that is judged as definitely heavier, and goes on until S judges as “lighter” twice in succession. The double series is repeated five times.

The following points must be carefully observed :

1. The series of canisters must be arranged behind the screen, so that S does not know which canister is taken.
2. The lifting of standard and variable must always be from the same place. To secure this a circle should be

chalked on the table, in which E sets each canister to be lifted.

3. The lifting must always be done with the same hand, at the same speed, and to the same height. For the timing the metronome is used, and there should be some practice in timing by both E and S, before beginning the experiment.

**Alternative Procedure**—(Method of Right and Wrong Cases, as in Exp. 13, p. 31). Five variables should be chosen, the lowest being 4 gr. above the standard, that is, No. 3. In this case "time errors" may be calculated by repeating the experiment with both time orders of lifting standard and variable. Each series should consist of ten judgments, that is, each variable compared twice with the standard, the procedure to get haphazard order, etc., being as in Exp. 13.

**Results**—Find the average weight judged equal to the standard, taking the middle equal from each series, ascending or descending the Method of Limits, or one from each series in the Method of Right and Wrong Cases. The difference between that average and the standard is, of course, the amount of the illusion, which may be given as a percentage of the standard.

## EXPERIMENT 64

### *Hand-Eye Co-ordination*

**Problem**—To measure the accuracy of hand-eye co-ordination under different conditions.

**Apparatus and Material**—Two semicircular plywood or thick cardboard plates, diameter 36 in., fixed 9 in. apart, and space at circumference closed with stout celluloid, on which is marked on outside a scale in degrees, numbered from zero at middle to 90 towards right and left, and with celluloid projecting  $\frac{3}{4}$  in. above surface of upper plate all round. Rider with white circular spot,  $\frac{1}{4}$  in. in diameter, to move along projecting edge, and provided below with a pointer to move along scale. Finger-cap to fit on forefinger, provided with a conical point for indicating on scale the position of the spot on rider.

**Procedure**—S sits with chin resting on top of apparatus. E places the pointer at a certain angle ; S points to the position of the pointer and E notes the error. The error is to be taken as *+ve* when the angle indicated by S is greater than the true angle ; the error is to be taken as *-ve* when the indicated angle is less than the true angle.

Five random values are to be taken in each quadrant for various combinations of hand and eye.

R.H.=right hand ;      L.H.=left hand ;  
R.Q.=right quadrant ;    L.Q.=left quadrant.

R. and L. are always to be interpreted as S's right and left.

In each case, both the true angles and the errors (positive or negative) should be recorded. When following the pointer, S should also turn his head; when fixating the centre, S. should also keep his head fixed and should not turn it to follow the pointer. In the cases where one eye fixates the centre, only a limited arc of the opposite quadrant will come within the field of vision—the values of the angles selected should be kept within this portion. At certain angles it will be found that the pointer will fall on the blind spot; these angles are to be discarded and others taken to make up the five for each series.

S should use some form of pointer to indicate the positions, e.g. thimble on index finger; care should be taken not to scratch perspex.

**Treatment of Results**—True angles and errors ( $+ve$  or  $-ve$ ) are to be tabulated as shown below. Find the mean error for each combination of eye, hand, quadrant and note whether there are any differences which can be attributed to the various factors.

	RH-RQ						RH-LQ						LH-RQ						LH-LQ					
	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5	
1. Both eyes following pointer.	Angle																							
	Error																							
2. Both eyes fixating centre.	Angle																							
	Error																							
2. Right eye following pointer.	Angle																							
	Error																							
4. Right eye fixating centre.	Angle																							
	Error																							
5. Left eye following pointer.	Angle																							
	Error																							
6. Left eye fixating centre.	Angle																							
	Error																							

One copy of results to be entered on proforma and left in lab.

## EXPERIMENT 65

### *Pursuit-Meter Experimeter*

**Problem**—To test S's ability to follow the random movement of a pointer on a dial by operating, either directly with a finger or by means of a wheel, the movement of another pointer.

**Apparatus and Material**—Craik's pursuit-meter, or Fulde's pursuit-meter, or any pursuit-meter constructed on similar lines. (In both these pursuit-meters the apparently random movement is actuated by a gramophone motor with an irregular cam. The main differences between them are: (1) that in Craik's pursuit-meter the "following" pointer is controlled by the forefinger, while in Fulde's it is controlled by a wheel; and (2) that in Craik's failure is recorded in watts on a D.C. or A.C. wattmeter, while in Fulde's it is recorded in more or less arbitrary units by means of a gas-meter counter.) Stop watch.

**Procedure**—E winds up motor. S stands in front of the apparatus, and places his forefinger on the button of the "following" pointer (Craik) or takes hold of the projecting pin of the wheel with his right hand (Fulde). E records the reading on the meter, then says "ready" and starts the motor. S tries to keep his pointer coinciding with the moving pointer until E says "stop"

and stops the motor, or until the motor stops automatically. He then reads the meter. S should try four "pursuits" at slow speed and four at quick speed. E and S should change functions at each "pursuit," which should continue for three minutes.

**Results**—The readings for each "pursuit" should be graphed, slow and quick being kept separate, the means should be calculated and compared. Practice, fatigue, distraction, etc. effects may be studied.

## EXPERIMENT 66

### *Group Projection Exercise*

**Note**—Projection experiments are essentially advanced experiments, but even elementary students may find such an experiment interesting and instructive, especially with the necessary hints from the instructor regarding its purpose and interpretation.

**Problem**—To bring to light personality trends.

**Material**—A set of six or eight untitled lantern slides representing without undue detail human scenes with one, two, or three persons. Lantern.

**Procedure**—E instructs group as follows: "You are going to be shown a series of lantern slides. Each will be on the screen for three minutes. Thereafter you will be given five minutes more to write the story (80 to 100 words) which the picture illustrates. Use your own imagination in constructing the story. There is no 'right' or 'wrong'."

Before each picture is shown say "now." Leave each on the screen for three minutes, and five minutes later say "stop."

**Results**—Each record should be identified by a *nom de plume*. The records should be collected and then distributed to the members of the group by any method which secures that no student has his own or his neighbour's record. The students should then attempt an analysis of the records given them according to a scheme outlined by the instructor. Any further use of the records is at the discretion of the instructor.



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